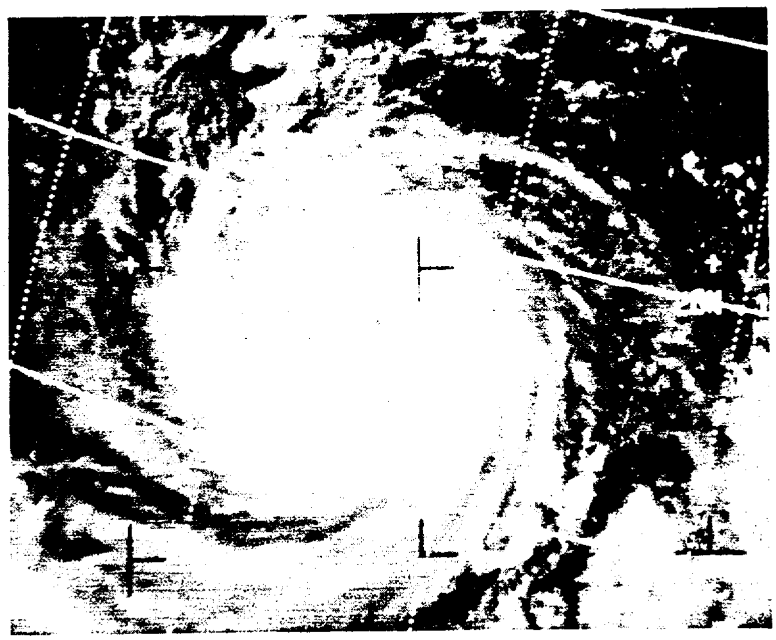
JTWC DIRECTOR

ANNUAL TYPHOON Report



NAVAL WEATHER SERVICE

1970

AIR WEATHER SERVICE

FLEET WEATHER CENTRAL/JOINT TYPHOON WARNING CENTER

Guam, Mariana Islands

SEE EDGE INDEX
ON BACK COVER

REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0704-0188

1. REPORT DATE (DD-MM-YYYY)	2. REPORT TYPE	3. DATES COVERED (FROM - TO)
01-01-1995	Annual Typhoon Report	xx-xx-1995 to xx-xx-1995

4. TITLE AND SUBTITLE 1970 Annual Typhoon Report Unclassified	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S) Slusser, Richard C. ; Kinney, John J. ;	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME AND ADDRESS Joint Typhoon Warning Center 425 Luapele Road Pearl Harbor, HI96860-3103	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME AND ADDRESS Naval Pacific Meteorology and Oceanography Center Joing Typhoon Warning Center 425 Luapele Road Pearl Harbor, HI96860-3103	10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
APUBLIC RELEASE
,

13. SUPPLEMENTARY NOTES
See Also ADM001257, 2000 Annual Tropical Cyclone Report Joing Typhoon Warning Center (CD includes 1959-1999 ATCRs). Block 1 and Block 3 should be 1970.

14. ABSTRACT
This report is published annually and summarizes Western North Pacific Tropical Cyclones. Annex A is added to summarize Tropical Cyclones from 180 degrees eastward to the North American Coast.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19. NAME OF RESPONSIBLE PERSON
			Public Release	236	Fenster, Lynn lfenster@dtic.mil
a. REPORT Unclassified	b. ABSTRACT Unclassified	c. THIS PAGE Unclassified			19b. TELEPHONE NUMBER International Area Code Area Code Telephone Number 703767-9007 DSN 427-9007

U. S. FLEET WEATHER CENTRAL
JOINT TYPHOON WARNING CENTER
COMNAVMARIANAS BOX 12
FPO SAN FRANCISCO 96630

RICHARD C. SLUSSER
Captain, United States Navy

COMMANDING

JOHN J. R. KINNEY
Lieutenant Colonel, United States Air Force

DIRECTOR, JOINT TYPHOON WARNING CENTER

STAFF

LCDR Jerry D. Jarrell, USN
CAPT David F. Solem, USAF
CAPT Charles D. Ables, USAF
1LT Charles R. Holliday, USAF
LTJG Richard A. Wagoner, USNR
ENS Richard H. Johnson, USNR
TSGT William W. Harra, USAF
AG1 Donald G. Stetler, USN
SSGT Travers D. Hanna III, USAF
SGT James R. Stevens, USAF
SGT Charles C. Johnson, USAF
AGAN David P. Bougher, USN
AGAN David L. Balint, USN
Miss Ann N. Smoot

CONTRIBUTOR

1LT Brian E. Heckman, USAF, 54 WRS

1970
ANNUAL TYPHOON REPORT

FOREWORD

This report is published annually and summarizes Western North Pacific Tropical Cyclones. Annex A summarizes tropical cyclones from 180 degrees eastward to the North American Coast.

When directed by CINCPAC in May 1959, CINCPACFLT redesignated Fleet Weather Central Guam as Fleet Weather Central/Joint Typhoon Warning Center (FWC/JTWC), Guam with the following responsibilities:

1. To provide warnings to U. S. Government agencies for all tropical cyclones north of the equator and west of 180 degrees longitude to the coast of Asia and Malay Peninsula.

2. To determine tropical cyclone reconnaissance requirements and assign priorities.

3. To conduct investigative and post-analysis programs including preparation of the Annual Typhoon Report.

4. To conduct tropical cyclone forecasting and detection research as practicable.

Air Force Asian Weather Central at Fuchu, coordinating with U. S. Navy Fleet Weather Facility Yokosuka, was designated as alternate JTWC in case of failure of FWC/JTWC Guam.

The JTWC is an integral part of FWC/JTWC Guam and is authorized to be manned by three Air Force and three Navy officers and five enlisted mean from each service. The senior Air Force officer is designated as Director, JTWC.

The Western Pacific Tropical Cyclone Warning System consists of the Joint Typhoon Warning Center, the U. S. Air Force 54th Weather Reconnaissance Squadron stationed at Andersen Air Force Base, Guam and U. S. Navy Airborne Early Warning Squadron ONE stationed at Naval Air Station, Agana, Guam.

The Central Pacific Hurricane Center (CPHC), Honolulu is responsible for the area from 180° eastward to 140°W and north of the equator. Warnings are issued in coordination with the FLEWEACEN Pearl Harbor and the Air Force Central Pacific Forecast Center, Hickam Air Force Base, Hawaii.

The Eastern Pacific Hurricane Center (EPHC), San Francisco is responsible for the area east of 140°N and north of the equator. Warnings are issued in coordination with the FLEWEACEN Alameda and the Air Force Hurricane Liaison Officer, McClellan Air Force Base, California.

The coordinating agencies under CINCPACFLT and CINCPACAF are responsible for further dissemination and, if necessary, local modification of tropical cyclone warnings to U. S. military agencies.

TABLE OF CONTENTS

CHAPTER 1

OPERATIONAL PROCEDURES

A. GENERAL

Services provided by the Joint Typhoon Warning Center (JTWC) include forecasts of tropical cyclone formation, intensity, direction and speed of movement and areal extent of damaging winds. The primary products of JTWC providing these services are the Tropical Cyclone Formation Alert issued when formation of a tropical cyclone is suspect, and tropical cyclone warnings issued in 1970 at 0500Z plus every six hours whenever tropical cyclones existed in the JTWC area.

FLEWEACEN Guam provides computer and meteorological/oceanographic analysis support for JTWC.

Communications services for JTWC are provided by the Nimitz Hill Message Center of NAVCOMMSTA Guam.

Prior to the 1970 typhoon season the Fleet Weather Central Guam Communications Center was consolidated with the larger Nimitz Hill Message Center. This caused many excessive delays in JTWC's outgoing traffic (primarily warnings, alerts, etc.) during the first few storms of the season. However after much effort on the part of the Nimitz Hill Message Center staff and the Operations Department of Fleet Weather Central Guam, excessive delays were greatly reduced by October 1970. The use of FLASH precedence on all warnings to U. S. forces afloat virtually eliminated excessive delays to these customers.

B. ANALYSES AND DATA SOURCES

1. FWC ANALYSES:

a. Surface polar stereographic projection analysis, Northern Hemisphere, Western Pacific area; 0000Z, 0600Z, 1200Z, and 1800Z.

b. Surface micro-analysis of South China Sea region; 0000Z, 0600Z, 1200Z, and 1800Z.

c. Surface mercator projection analysis, Northern and Southern Hemisphere, Western Pacific and Indian Ocean area; 0600Z and 1800Z.

d. Sea surface temperature charts; daily.

2. JTWC ANALYSES:

a. Gradient level (3,000 feet) streamline analysis and nephanalysis of satellite-observed significant cloudiness; 0000Z and 1200Z.

b. 700 mb, 500 mb, and 200 mb mercator projection contour analysis; 0000Z and 1200Z.

c. Reconnaissance data. Observations from weather reconnaissance aircraft are plotted on large scale sectional charts.

d. Time cross sections of selected tropical stations.

e. Time sections of surface reports for selected tropical stations.

f. Additional and more frequent analyses similar to those above during periods of tropical cyclone activity.

3. SATELLITE DATA:

The quantity and quality of satellite data continued to increase during the 1970 typhoon season. ESSA-8 continued to be the primary source of satellite data during the morning hours. These data were interspersed with NIMBUS III satellite passes. In February 1970 the first ITOS satellite became operational providing afternoon satellite coverage, and in December 1970 the second of the ITOS series was launched giving additional afternoon coverage.

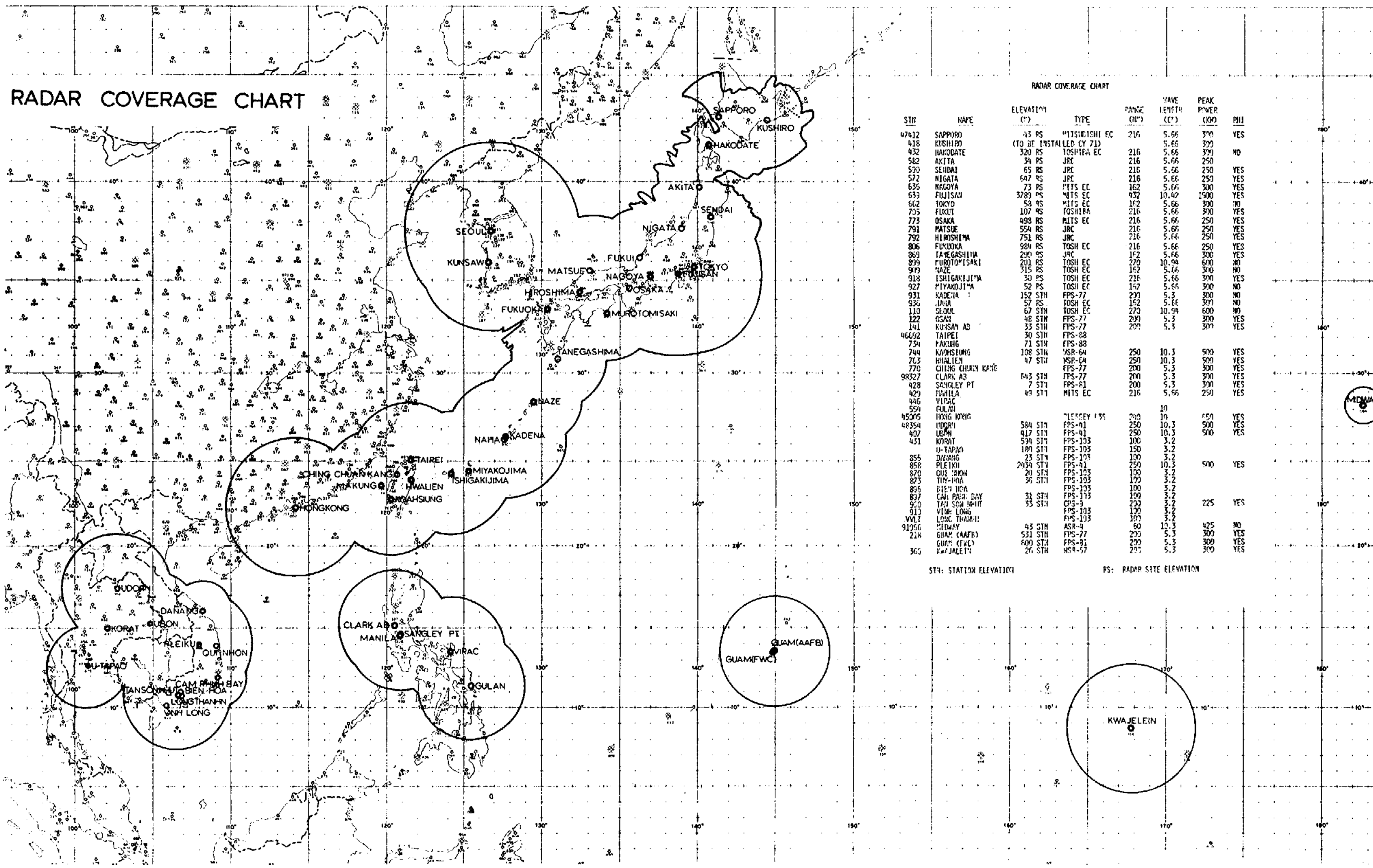
During the night both ITOS-1 and NIMBUS III IR coverage was received until 25 September when the NIMBUS equipment failed. Only the center portion of a DRIR pass gives an undistorted view of cloud patterns, therefore there is a significant gap between each sub-orbital track which is not viewed clearly. The chance of a disturbance being within the undistorted portion of the satellite's swath was significantly reduced when the NIMBUS III equipment failed. The IR passes were also used for briefing reconnaissance crews making early morning investigative flights into tropical disturbances.

Excellent satellite coverage was received between 120°E and 160°E using Fleet Weather Central Guam's APT equipment. Fleet Weather Central Pearl Harbor furnished live APT coverage for area east of 160°E via dedicated landline. Sparse coverage of the area west of 120°E was furnished by Clark AFB by means of a taped pass relayed over AUTOVON. Unfortunately the poor quality of the taped data reduced its usefulness.

4. RADAR:

Land radar reports, when available, were used for tracking tropical cyclones during the 1970 typhoon season. Once a storm moved within range of a land radar site, reports were usually received hourly.

Figure 1-1 shows the network of land radar stations in the Western Pacific and Southeast Asia. Most of the major



RADAR COVERAGE CHART

STN	NAME	ELEVATION (FT)	TYPE	RANGE (NM)	WAVE LENGTH (CM)	PEAK POWER (KW)	MTI
47412	SAPPORO	43 RS	MITSUBISHI EC	216	5.66	300	YES
418	KUSHIRO	(TO BE INSTALLED CY 71)			5.66	300	
432	HAKODATE	320 RS	TOSHIBA EC	216	5.66	300	NO
582	AKITA	34 RS	JRC	216	5.66	250	
590	SENDAI	65 RS	JRC	216	5.66	250	YES
572	NIGATA	647 RS	JRC	216	5.66	250	YES
635	NAGOYA	73 RS	MITS EC	162	5.66	300	YES
639	FUJISAN	3780 RS	MITS EC	432	10.42	1500	YES
662	TOKYO	58 RS	MITS EC	162	5.66	300	NO
705	FUKUI	107 RS	TOSHIBA	216	5.66	300	YES
773	OSAKA	498 RS	MITS EC	216	5.66	250	YES
791	MATSUE	554 RS	JRC	216	5.66	250	YES
792	HIROSHIMA	751 RS	JRC	216	5.66	250	YES
806	FUKUOKA	984 RS	TOSH EC	216	5.66	250	YES
869	TANEGASHIMA	290 RS	JRC	162	5.66	300	YES
899	MUROTOMISAKI	201 RS	TOSH EC	270	10.94	600	NO
909	NAZE	315 RS	TOSH EC	162	5.66	300	NO
918	ISHIGAKIJIMA	30 RS	TOSH EC	216	5.66	300	YES
927	MIYAKOJIMA	52 RS	TOSH EC	162	5.66	300	NO
931	KADENA	152 STN	FPS-77	200	5.3	300	NO
936	NAHA	57 RS	TOSH EC	162	5.66	300	NO
110	SEOUL	67 STN	TOSH EC	270	10.94	600	NO
122	OSAN	48 STN	FPS-77	200	5.3	300	YES
141	KUNSAN AB	35 STN	FPS-77	200	5.3	300	YES
46692	TAIPEI	30 STN	FPS-88				
734	MAKUNG	71 STN	FPS-88				
744	KAOHSIUNG	108 STN	MSR-64	250	10.3	500	YES
763	HWALIEN	47 STN	MSR-64	250	10.3	500	YES
770	CHING CHUAN KANG		FPS-77	200	5.3	300	YES
98327	CLARK AB	543 STN	FPS-77	200	5.3	300	YES
428	SANGLEY PT	7 STN	FPS-81	200	5.3	300	YES
429	MANILA	49 STN	MITS EC	216	5.66	250	YES
446	VIRAC						
554	GULAN				10		
45005	HONG KONG		PLESSEY 43S	200	10	650	YES
48354	UDORN	584 STN	FPS-41	250	10.3	500	YES
407	UBAN	417 STN	FPS-41	250	10.3	500	YES
431	KORAT	594 STN	FPS-103	100	3.2		
	U-TAPAO	180 STN	FPS-103	150	3.2		
855	DANANG	23 STN	FPS-103	100	3.2		
858	PLEIKU	2434 STN	FPS-41	250	10.3	500	YES
870	QUI NHON	20 STN	FPS-103	100	3.2		
873	TUY-HOA	36 STN	FPS-103	100	3.2		
896	BIEN HOA		FPS-103	100	3.2		
897	CAM RANH BAY	31 STN	FPS-103	100	3.2		
900	TAN SON NHUT	33 STN	CPS-9	200	3.2	225	YES
913	VINH LONG		FPS-103	100	3.2		
VVLT	LONG THANH		FPS-103	100	3.2		
91066	MIDWAY	43 STN	ASR-4	60	10.3	425	NO
218	GUAM (AAFB)	531 STN	FPS-77	200	5.3	300	YES
	GUAM (FWC)	600 STN	FPS-81	200	5.3	300	YES
365	KWAJALEIN	26 STN	MSR-57	200	5.3	300	YES

STN: STATION ELEVATION   RS: RADAR SITE ELEVATION

FIGURE 1-1

population centers have excellent radar coverage, especially in Japan. Pertinent data for most stations are included in the insert. Japan's Mt. Fuji radar has the greatest range due to its high elevation and extreme power. An example of the radar presentation from the Mt. Fuji site is given in Chapter 5 (Typhoon Clara).

5. COMPUTER PRODUCTS, 0000Z and 1200Z:

a. Hemispheric analyses and barotropic prognoses for 1000 mb, 700 mb, 500 mb, 300 mb, and 200 mb. (Replaced by Primative Equation model Progs in mid 1970).

b. Decomposition fields of the 500 mb (SD, SR and SL) analyses and prognoses. The SD, SR, and SL fields correspond roughly to small scale disturbances, mean flow and long wave pattern respectively.

c. Computer analysis of tropical streamlines for the 700-, 500-, 400-, 300-, 250-, and 200-mb levels from FWC Pearl fields were used in 1970.

d. The HATRACK typhoon steering program based on SR prognostic fields was used on an operational time basis as a forecast aid.

e. The TYRACK typhoon steering program was operationally used during the 1970 season. This program utilizes the FWC Pearl tropical streamline fields for determining forecast movement.

f. In an effort to aid in assessment of development potential, tropospheric vertical shear charts based on FWC Pearl streamline fields were produced twice daily throughout most of the 1970 season along with similarly derived 250 mb and 700 mb divergence charts for the Western Pacific. Vertical shear-values were computed by vector subtraction of the 700 mb wind from a mean of the 400 mb, 300 mb, 250 mb, and 200 mb winds.

g. The TYFOON analog climatological program was first used in 1970 beginning with Typhoon Wilda (August). This program was developed under NAVWEARSCHFAC sponsorship by the National Weather Records Center, and extensively modified at NAVWEARSCHFAC.

C. FORECAST AIDS

1. CLIMATOLOGY:

The following climatological publications were utilized:

a. Tropical Cyclones in the Western Pacific and China Sea Area (Royal Observatory, Hong Kong), covering 70 years of typhoon tracks.

b. Climatological Aid to Forecasting Typhoon Movement (1st Weather Wing).

c. Climatological 24-Hour Typhoon Movement (McCabe, J. T., 1961).

d. Western Pacific Typhoon Tracks, 1950-1959 (FWC/JTWC).

e. Far East Climate Atlas (1st Weather Wing, February 1963).

f. Annual Typhoon Reports, 1959-1969 (FWC/JTWC).

g. A Climatology of Tropical Cyclones and Disturbances of the Western Pacific with a Suggested Theory for Their Genesis/Maintenance (Gray, Wm. 1970) NAVWEARSCHFAC Tech Paper No. 19-70.

2. PERSISTENCE:

Extrapolation of storm movement using 12 to 18 hour mean speed and direction was the most reliable objective method for 24 hour forecasts.

3. OBJECTIVE TECHNIQUES:

During 1969 the following individual objective forecasting methods were employed:

a. ARAKAWA - surface pressure grid model.

b. HATRACK - based on 700 mb SR prognosis.

c. HATRACK - based on 500 mb SR prognosis.

d. TYRACK - based on program-selected best steering level from Pearl tropical fields.

e. TYFOON - analog weighted mean track and best analog track.

(See Chapter 3 for technique evaluation.)

D. FORECASTING PROCEDURES:

1. TRACK FORECASTING: An initial track based on persistence blended subjectively with climatology is developed for a 3 to 4 day period. This initial track is subjectively modified by use of the following:

a. Recent steering is evaluated by considering the latest upper air analyses as representative of the average upper air flow over the past 24 hours. (The latest upper air analyses are normally about 12 hours old thus roughly represent the mid-point of the last 24 hour time interval.) By this technique actual past 24 hour movement serves to indicate the best steering level as well as the effectiveness of steering.

b. Objective techniques are considered, weight is given to techniques according to recent past performance.

c. 24 hour height change analyses and progs are used to forecast track/speed changes. (Hoover 1957).

d. The prospects of recurvature must be evaluated for all westward moving storms. The basic tools for this evaluation are accurate continuity on mid-latitude troughs and numerical progs to indicate changes in amplitude or movement. Relative position and strength of the subtropical ridge and northward beta force are also important considerations.

e. Finally a check is made against climatology to ascertain the likelihood of the forecast. If the forecast track is climatologically unusual a reappraisal of the forecast rationale is made and adjustments are made if warranted.

2. INTENSITY FORECASTING: Intensity forecasts are made by using a linear extrapolation of past intensification subjectively tempered with climatology as a first guess. This first guess is modified considering availability of upper tropospheric evacuation, 850-700 mb temperatures, sea surface temperatures, and possible terrain. All these considerations are predictions along the forecast track and thus dependent on the accuracy of the forecast positions as well as the accuracy of their evaluations.

E. WARNINGS:

Tropical cyclone warnings are numbered consecutively without regard for upgrading or downgrading of the storm between intensity stages. If warnings are discontinued and the storm again intensifies, warnings are numbered consecutively from the last warning issued. Amended or corrected warnings are

given the same number as the warnings they modify. Forecast positions are issued at 0500Z plus every six hours as follows:

Tropical Depressions	12 hr and 24 hr
Typhoons and Tropical Storms	12, 24, and 48 hr (72 hr at 11Z and 23Z only)

Forecast periods are stated with respect to warning time. Thus a 24 hour forecast verifies 26 hours after the aircraft fix data, 29 hours after the latest surface synoptic chart and 29 to 35 hours after the latest upper air charts.

Warning forecast positions are verified against the corresponding post analysis "best track" positions. A summary of results from 1970 is presented in Chapter 4.

F. PROGNOSTIC REASONING MESSAGE:

Whenever warnings are being issued, an amplifying message is issued at 00Z and 12Z. This prognostic reasoning message is intended to provide meteorological units with technical and non-technical reasoning appropriate to the behavior of current storms and the logic of the latest JTWC forecasts.

G. TROPICAL WEATHER SUMMARY:

This message is issued daily from May through December and otherwise when significant tropical cyclogenesis is forecasted or observed. It is issued at 0600Z and describes the location, intensity and likelihood of development of all tropical low pressure areas and significant cloud "blobs" detected by satellite.

H. TROPICAL CYCLONE FORMATION ALERT:

Alerts are issued when the formation of a tropical cyclone is considered possible or probable. Alerts are typically used to cover a suspect area before reconnaissance can be conducted and additionally to cover an existing tropical depression of low or unknown development potential. These messages are issued at any time, are usually valid for 24 hours unless cancelled, superseded or extended.

REFERENCE:

Hoover, E. W., Devices for Forecasting Movement of Hurricanes, Manuscript of the U. S. Weather Bureau, Jan. 1957.

CHAPTER 2

RECONNAISSANCE

A. GENERAL

The Tropical Cyclone Warning Service depends on aircraft reconnaissance to fix the location and to determine the intensity of tropical cyclones. Due to their physical characteristics, their development and movement over vast oceanic areas, land and ship reports are not sufficient for these determinations. Satellite pictures are an increasingly valuable aid, particularly in the initial detection of the formative stages of tropical cyclones, but at the present time the interpretation of cyclone intensity and center location is not sufficiently accurate for operational use. Satellite data is used primarily as the basis for scheduling aircraft investigative flights.

B. RECONNAISSANCE REQUIREMENTS

JTWC reconnaissance requirements for investigations, fixes, and/or synoptic tracks are relayed to the Tropical Cyclone Reconnaissance Coordinator (TCRC) each day by phone with message confirmation. This includes the area for investigation, the forecast position of the cyclone at the levied fix times, and/or a standard synoptic track. The TCRC then assigns the missions to the Air Force's 54th Weather Reconnaissance Squadron (54WRS) operating WC-130 aircraft and/or the Navy's Airborne Early Warning Squadron ONE (VW-1) operating WC-121 aircraft. Both squadrons are based on Guam but often stage from other bases according to the relative location of the reconnaissance area and assets.

Four fixes per day are levied on all tropical cyclones within the JTWC area of responsibility. Fixes are scheduled at six hourly intervals for two hours before warning time. Additional fixes and other information may be requested by operational commanders through the TCRC when such additional information is needed to make operational decisions. These requests are honored as resources permit.

C. EVALUATION OF DATA

Eye data from tropical cyclones are provided by low level penetration, intermediate level penetration, or radar fixes from outside the center. Penetration fixes provide the most data about the cyclone. Of particular interest is the minimum sea level pressure in the center of the cyclone. Radar fixes are made from outside the cyclone center and are based on a "hole" in the radar presentation or the estimated center of the spiral banding. Penetration fixes are made whenever possible but often the small size of the eye combined with the intensity of the winds prohibit penetration for safety of flight.

An evaluation was made of the deviations of the tropical cyclone center fixes from the best track of the storm. (See Chapter 3.) Only right angle deviation was considered. Aircraft fixes from 1967 through 1969 were used along with satellite bulletin positions for 1969 and 1970. The median deviation for aircraft penetration fixes was 3 N.M.; for aircraft radar fixes, 5 N.M.; and for satellite bulletin positions, 16 N.M. The other percentiles and extremes are as shown in Table 2-1.

FIX RIGHT ANGLE DEVIATION FROM BEST TRACK (NM)

	ACFT PENETRATION -- 681 CASES 1967-70	ACFT RADAR -- 229 CASES 1967-69	SATELLITE -- 174 CASES 1969-70
MEDIAN	3	5	16
68% WITHIN	5	9	28
95% WITHIN	15	21	72
EXTREME	40	58	83

TABLE 2-1

Aircraft penetrations are considered the most accurate followed closely by aircraft radar with satellite fixes a distant third. From these figures one can see that while satellite data are extremely valuable in the initial detection of tropical cyclogenesis, aircraft fixes must continue to be the primary source for locating tropical cyclones as the initial position from which forecasts are made.

D. PERIPHERAL DATA

In order to gather more useful peripheral data from around the cyclone center, standard peripheral data tracks were developed by JTWC in coordination with the reconnaissance squadrons. Figure 2-1 shows the tracks agreed on. Tracks Alfa, Bravo, and Charlie are essentially box patterns of different sizes with the pattern to be flown depending on the extent and intensity of the storm. Track Delta is used for rapidly accelerating cyclones or for ridge investigations along a specified radial from the cyclone center. Normally, the tracks can only be used when the same aircraft is making two fixes six hours apart. JTWC recommends a track to be flown but the ultimate decision as to peripheral track rests with the aircraft commander after arrival on the scene.

PERIPHERAL TRACKS

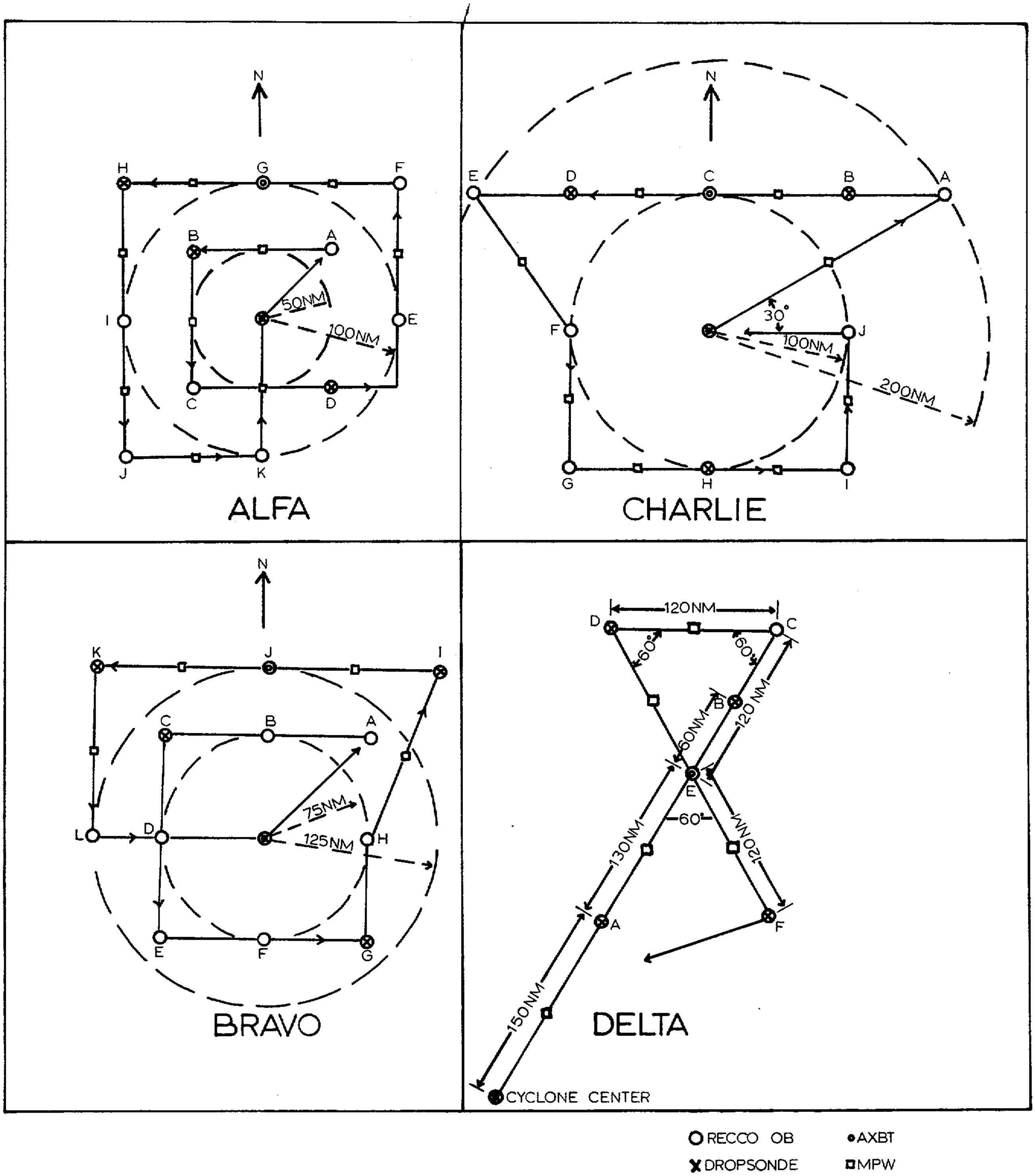


FIGURE 2-1

Figure 2-2 shows an example of Track Bravo flown around Typhoon Hope on 25 September 1970. For clarity, only the winds are plotted around the fixes in this example. Previously, the standard peripheral track was a circle of 150 N.M. radius around the storm. This was often too far from the storm center to provide useful data. With these new tracks, the observations are taken as close to the storm center as flight safety and crew comfort will permit. In the example, Typhoon Hope had maximum surface winds of 120 knots on the first fix and 100 knots on the second fix. The aircrew was able to fly Track Bravo without difficulty. This was at one half of the previous standard radius of 150 N.M.

E. COMMUNICATIONS

The primary method for relay of the eye/center message from the aircraft to JTWC is by means of a direct phone patch with the aircraft. Andersen Airways is the primary center and is used whenever possible. Other centers are Clark, Kadena, and Fuchu Airways. JTWC and the weather monitor at Andersen copy the eye/center message simultaneously. Routine reconnaissance observations are copied by the weather monitor and transmitted over the teletype without a phone patch to JTWC.

Table 2-2 shows a summary of the delay times for the receipt of fix data for 1970.

DELAY IN RECEIPT OF RECONNAISSANCE DATA FOR 1970

METHOD	NUMBER OF CASES	MAX DELAY TIME	AVG DELAY TIME	MIN DELAY TIME
PHONE PATCH OR PHONE RELAY	481	2hr 03min	0hr 23min	0hr 02min
SDE9	54	3hr 30min	0hr 37min	0hr 10min*
AUTODIN	2	2hr 05min	1hr 45min	1hr 25min
DALS**	1	0hr 25min	0hr 25min	0hr 25min

*Preliminary eye fix
**Two partial eye messages also received

TABLE 2-2

The delay time is defined as the difference between the time of the fix and the time of receipt of the completed message in JTWC. About ninety percent of the fixes were received by phone patch or phone relay with an average delay of 23 minutes. (Phone relay method from the weather monitor was

TYPHOON HOPE TRACK
BRAVO 25 SEP 1970

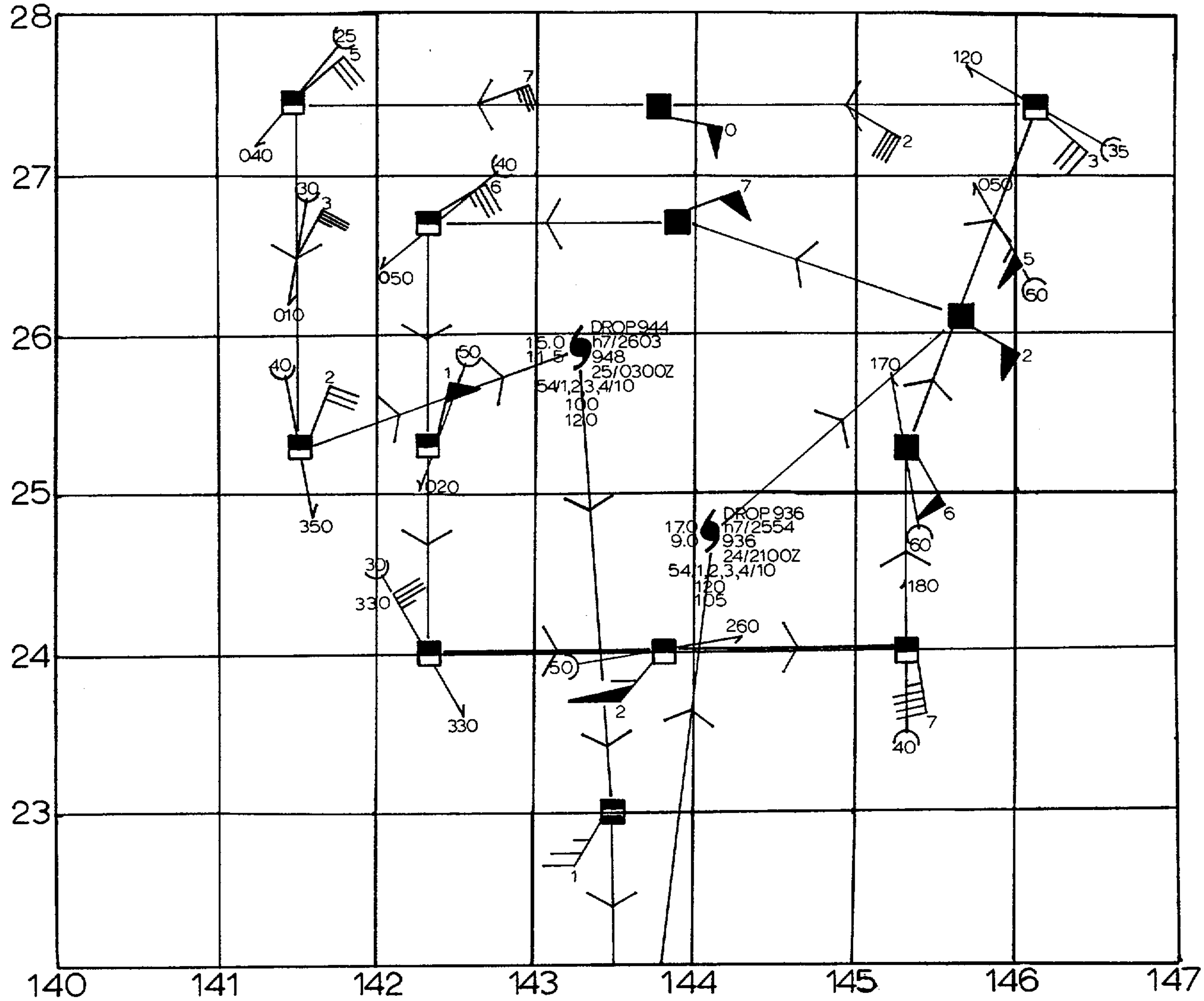


FIGURE 2-2

used in a few cases when the signal from the aircraft was too weak to be copied by JTWC.) About ten percent of the eye fixes were passed from the weather monitor to JTWC via the on-island teletype circuit (SDE9) with an average delay of 37 minutes. Most of these were preliminary fixes in an abbreviated format.

A comparison of delay times for the past five years is shown in Table 2-3.

COMPARISON OF DELAY TIMES WITH PREVIOUS YEARS

	1966	1967	1968	1969	1970
MAX DELAY TIME	4HR 33M	11HR 20M	6HR 25M	2HR 11M	3HR 30M
AVG DELAY TIME	1HR 02M	0HR 43M	0HR 25M	0HR 22M	0HR 25M
MIN DELAY TIME	FEW MIN	FEW MIN	FEW MIN	0HR 01M	0HR 02M
% EYE MSGS DELAYED OVER 1 HOUR	38%	16%	4%	2.8%	5%
# FIXES RECEIVED AFTER WARNING TIME	30*	23	6	3	5
% FIXES RECEIVED AFTER WARNING TIME	5.4%	3.1%	0.7%	0.6%	0.9%

*Fixes scheduled 3 hours prior to warning time vice 2 hours after 1966.

TABLE 2-3

Statistics for the past three years show a leveling off in all values. These are all within acceptable limits. Little or no reduction in delay times can be foreseen within the present system.

F. AIRCRAFT RECONNAISSANCE SUMMARY

Aircraft reconnaissance missions for 1970 included 211 synoptic tracks, 168 investigations, and 439 levied fix missions completed. There were also 60 nonlevied preliminary and intermediate fixes made. A total of 10 levied fixes or investigatives were missed; five of these were for fixes when two storms were in progress at the same time. This gives a total of 607 levied fixes and investigatives completed which is only slightly below the average of 644 for the period 1962 through 1970. Figure 2-3 shows the monthly distribution of

MONTHLY DISTRIBUTION OF RECONNAISSANCE REQUIREMENTS FOR 1970

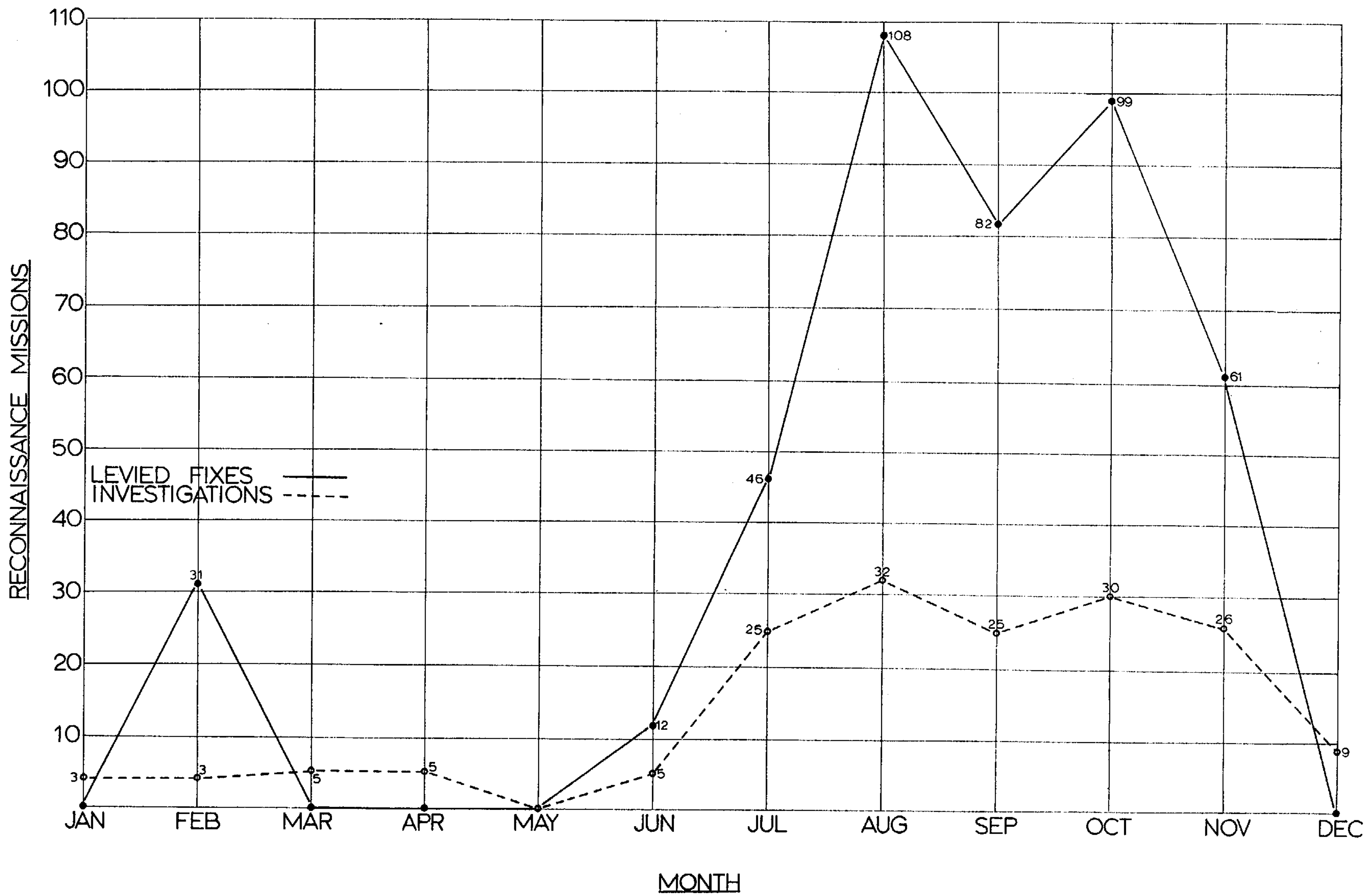


FIGURE 2-3

reconnaissance requirements for 1970. Few missions were required during the first half of the year with 88% of the requirements occurring during the five-month period July through November. Fixes for this past year show a peak caused by Typhoon Nancy in February. Cyclones may occur during any month of the year but normally there is not more than one typhoon occurring during the first four months. About 80% of the reconnaissance requirements normally occur during July through November.

G. RECONNAISSANCE EFFECTIVENESS

Based on the credit system shown in Table 2-4, a percent effectiveness was computed for cyclone fixes, investigations, and for the combined effectiveness. This system is only an evaluation of the time the fix was made compared to the levied fix time. No provision is included for type or quality of fix.

Of 470 levied cyclone fixes, 415 were made on time with another 23 missions falling into the Class 2 category. Twenty fixes were made either early or late, 8 fixes were missed completely while the remaining four missions failed to fix an existing center. Out of 1,410 points possible, 1,341 were earned or a fix effectiveness of 95.1%. Of the 170 levied investigations, 2 missions were missed, 46 resulted in center fixes, and 122 missions were flown into suspect areas without a detectable center. A total of 502 points were earned out of a possible 510 for a 98.4% investigative effectiveness. The combined effectiveness for fixes and investigatives was 96.0%. The average recon effectiveness for the last five years is 96.6% with very little deviation from year to year. This average value apparently approaches optimum utilization of reconnaissance resources available to WESTPAC.

RECON CREDIT DEFINITIONS WITH MISSIONS FOR 1970

CLASS	DEFINITION	POINTS	CRITERIA	1970
1	Full Credit Fix	+3	Fix made from 1 hour before to ½ hour after levied time.	415
2	Full Credit Fix	+3	Aircraft in area assigned from 1 hour before to ½ hour after levied time but unable to locate a center or unforecast cyclone acceleration caused the cyclone to be too distant to reach on time. Also fix attempted but not made due to reasons beyond the control of the squadron such as cyclone moved over land, restricted flying area, clearance problems, etc.	23
3	Early/Late Fix	+2	Fix made more than 1 hour but not more than 1½ hours before or more than ½ hour but not more than 2 hours after levied time.	15
4	Very Early/ Very Late Fix	+1	Fix made more than 1½ hours before or more than 2 hours after levied time.	5
5	Fix Attempted But Not Made	0	Recon provided some useful peripheral data but no fix was made. Reasons may include such things as mechanical trouble, low fuel, etc.	4
6	Missed Fix or Investigative	-1	Missed fix not covered by classes above or missed investigative.	8/2
7	Full Credit Fix	+3	Fix made on investigative flight or synoptic track. Detailed eye/ center message received.	46
8	Full Credit Investigative	+3	Investigative flight about a point; no fix made.	122
9	No Credit Fix	0	Preliminary or intermediate fix not levied.	60

NOTE: All levied fixes and investigatives have a potential of +3 points.

TABLE 2-4

CHAPTER 3

TECHNICAL NOTES

A. COMPARISON OF OBJECTIVE TECHNIQUES

1. GENERAL

Verification of objective forecasting techniques has been continuous since 1967 although year-to-year modifications and improvements have prevented any long period comparison of more than a few of the techniques. None of the objective forecasts used now go beyond the simple steering concept of a point vortex in a smoothed flow field with adjustments based on past movement. Development and its important relationship to movement are excluded in all objective forecasts.

TYFOON, a new statistical analog technique for Western Pacific typhoons (Jarrell and Somervell, 1970) that closely resembles HURRAN, its Atlantic counterpart (Hope, et al 1970), was first tested during the 1970 season. While designed as a forecast aid, verification is presented here along with the other objective techniques. This technique provided for the first time verifiable objective 72 hour forecasts.

2. DISCUSSION OF OBJECTIVE TECHNIQUES

a. EXTRAPOLATION - Past 24 hour movement is extrapolated to 24 and 48 hours.

b. ARAKAWA (1963) - Grid overlay values of surface pressure are entered into regression equations and hand-computed for storms 50 kts or greater.

c. HATRACK 700 mb, 500 mb (Hardie, 1967) - Point vortex advected on the 700 mb and 500 mb analysis or prognostic SR (space mean) field in six-hour time steps up to forecast period of 66 hours (without bias correction).

d. RENARD 700 mb/500 mb PROG (FWC/JTWC, 1968) - Combination of HATRACK 700 mb longitude and HATRACK 500 mb latitude.

e. TYRACK - Tropical cyclone movement forecast on FWC Pearl tropical fields (Hubert, 1968) with capability for subjective program control.

f. WEIGHTED CLIMO (Jarrell and Somervell, 1970) - Program outputs forecast positions as the centers of probability ellipses out to 72 hours based on a group of analog storms which occurred within a time/space envelope centered about the date and position of the storm being forecast. Ellipses are based on the analog population weighted according to similarity to the existing storm.

g. FIRST ANALOG - Forecast positions out to 96 hours based on the track of the most similar analog storm.

3. TESTING AND RESULTS

Verification results for 24, 48, and 72 hour forecasts appear in Table 3-1 with the techniques listed in order of accuracy based on homogeneous comparisons.

OBJECTIVE TECHNIQUE COMPARISON

24 HOUR		48 HOUR		72 HOUR	
EXTRAPOLATION	(121)	WEIGHTED CLIMO	(216)	WEIGHTED CLIMO	(310)
WEIGHTED CLIMO	(108)	EXTRAPOLATION	(273)	ANALOG	(384)
ARAKAWA	(142)	ARAKAWA	(246)		
TYRACK (BETA=2)	(143)	TYRACK (BETA=2)	(297)		
ANALOG	(127)	ANALOG	(263)		
TYRACK (BETA=5)	(151)	TYRACK (BETA=5)	(330)		
RENARD	(173)	RENARD	(370)		
HATRACK 700	(181)	HATRACK 700	(382)		
HATRACK 500	(193)	HATRACK 500	(380)		

TABLE 3-1

The number shown after each technique is the average error for all forecasts by that method. The complete set of homogeneous comparisons in Table 3-2 contains the data used for ranking the techniques. Individual errors greater than 500 N.M. for 24 hours and 1000 N.M. for 48 hours were discarded based on assumption that recording or processing errors were involved.

Comments on the performance of the objective technique for the 1970 season follow:

a. In no case, homogeneous or non-homogeneous, did the mean for any of the techniques better the official JTWC forecast mean.

b. EXTRAPOLATION continues to be superior for short range (24 hour) accuracy although only by a slight margin over WEIGHTED CLIMO. For the 48 and 72 hour forecasts, however, WEIGHTED CLIMO performed best. The substantial improvement in the longer range JTWC official forecast has been for a large part attributed to the reliable guidance of this new technique, which itself provided forecasts superior to all pre-1970 48 and 72 hour mean JTWC forecasts.

It should be remarked that the use of the analog forecast is limited to those cases with adequate historical sample sizes, thereby reducing its availability for some of the more difficult forecast situations. This shortcoming is partially reflected by the relatively low number of WEIGHTED CLIMO forecasts.

LEGEND

NUMBER OF CASES	X-AXIS TECHNIQUE ERROR
Y-AXIS TECHNIQUE ERROR	ERROR DIFFERENCE Y-X

JTWC	413	104																		
	104	0																		
XTRP	316	103	318	121																
	121	19	121	0																
ARKW	171	98	158	123	172	142														
	141	44	146	23	142	0														
HT7P	223	103	191	119	114	134	224	181												
	181	78	182	63	186	53	181	0												
TYB2	227	102	197	118	106	136	169	177	228	143										
	142	40	142	24	143	7	144	-33	143	0										
HT5P	220	102	189	117	113	133	214	175	164	143	221	193								
	192	90	192	75	191	58	188	13	194	51	193	0								
RD57	219	103	188	119	109	134	218	177	165	143	215	190	220	173						
	172	69	170	51	162	28	170	-7	173	31	170	-20	173	0						
TYB5	257	102	223	117	134	132	192	188	206	138	187	196	188	180	258	151				
	151	49	149	32	141	9	150	-38	149	11	150	-47	149	-31	151	0				
CLIW	80	91	65	100	44	105	48	171	60	127	49	189	47	172	58	139	80	108		
	108	17	102	2	99	-6	111	-60	111	-16	109	-80	109	-63	106	-33	108	0		
ANA1	79	89	64	100	43	106	47	172	59	127	48	190	47	172	57	136	79	107	79	127
	127	38	132	32	135	29	129	-43	136	9	123	-67	129	-43	130	-6	127	20	127	0
	JTWC		XTRP		ARKW		HT7P		TYB2		HT5P		RD57		TYB5		CLIW		ANA1	

24-HOUR

JTWC	258	193																		
	193	0																		
XTRP	185	184	196	273																
	254	70	273	0																
ARKW	105	175	92	251	105	246														
	246	71	252	1	246	0														
HT7P	132	185	119	264	61	254	141	382												
	388	203	388	124	390	136	382	0												
TYB2	150	175	133	237	68	255	114	378	158	297										
	290	115	300	63	266	11	318	-60	297	0										
HT5P	127	185	113	262	64	247	130	358	109	307	136	380								
	387	202	376	114	387	140	376	17	381	74	380	0								
RD57	127	185	114	261	60	252	136	373	110	306	128	370	136	370						
	377	193	370	109	382	130	370	-3	374	68	350	-20	370	0						
TYB5	162	178	151	245	81	253	125	381	145	295	120	384	121	374	171	330				
	326	148	335	90	324	71	341	-40	315	20	333	-51	335	-39	330	0				
CLIW	70	186	57	212	39	236	41	382	52	253	42	386	39	368	53	299	71	216		
	216	30	211	-2	201	-36	230	-153	212	-41	227	-160	229	-139	213	-86	216	0		
ANA1	64	183	53	211	39	236	38	380	48	258	40	396	36	366	49	301	65	214	65	263
	264	82	278	68	283	47	268	-113	268	10	262	-134	268	-99	276	-25	263	49	263	0
	JTWC		XTRP		ARKW		HT7P		TYB2		HT5P		RD57		TYB5		CLIW		ANA1	

JTWC = OFFICIAL JTWC SUBJECTIVE FORECAST
XTRP = EXTRAPOLATION
ARKW = ARAKAWA
HT7P = HATRACK 700 MB PROG
HT5P = HATRACK 500 MB PROG
TYB2 = TYRACK (BETA=2)
TYB5 = TYRACK (BETA=5)
RD57 = RENARD 500/700 MB
CLIW = WEIGHTED CLIMO
ANA1 = FIRST ANALOG

48-HOUR

JTWC	39	302				
	302	0				
CLIW	39	302	63	310		
	304	3	310	0		
ANA1	30	257	46	327	46	384
	364	108	384	57	384	0
	JTWC		CLIW		ANA1	

72-HOUR

TABLE 3-2

EXTRAPOLATION errors can be considered to be a good indicator of the difficulty of a forecast and similarly be a good measure of forecast skill. Keeping this in mind, it is noteworthy that the improvement of the JTWC official forecast over EXTRAPOLATION has increased from 5 percent in 1968 to 13 percent in 1969 to 15 percent in 1970.

c. ARAKAWA ranked third in accuracy for both 24 and 48 hour forecasts.

d. Of the computer techniques, TYRACK (BETA=2) verified with the lowest average error. Controls for adjusting tropical cyclone movement were added to the TYRACK program in 1970, but forecaster and computer time for testing was lacking.

The only control parameter tested was BETA, a variable northerly component added to the motion, and optimum results are noted for BETA=2. However, only a comprehensive testing using all combinations of the control parameters will lead to more accurate and reliable TYRACK forecasts.

e. FIRST ANALOG, although not among the top techniques, often provided useful guidance since characteristics of the analog storm and surrounding environmental conditions were available for comparison.

f. RENARD 700 mb/500 mb was again superior to HATRACK 700 mb and HATRACK 500 mb. HATRACK errors for forecasts based on analysis and prognostic fields were within 2 percent of each other for the 1970 season so their results are combined in Tables 3-1 and 3-2.

4. DISCUSSION AND PLANS FOR 1971 SEASON

Rapidly-acquired confidence in the analog technique as a reliable forecast guidance for both the short and long range has assured its continued use in 1971 with major emphasis on the climatological weighted mean positions. Verification of best analog forecasts will likely be discontinued.

A modified HATRACK technique developed by Renard et al. (1970) that corrects for recent error trends in the basic HATRACK prognostic forecast will be incorporated into the set of 1971 objective aids. This modified technique permits forecasts out to 48 hours. In addition, improvement to HATRACK is hoped for in a modification by the FWC computer section for the program to run on SL prog fields rather than SR progs.

Efforts to improve the TYRACK forecasts are also planned. A worthwhile testing of the control parameters on an

operational basis is possible with the desired result of reducing the arbitrariness in assigning values to the parameters and the subsequent reduction of forecast error.

B. TYPHOON FORECASTING ERROR IMPROVEMENT

1. INTRODUCTION

Over the years a gradual improvement has been noted in mean errors for typhoon forecasts. The 1970 errors were all-time lows for WESTPAC typhoons. Since mean errors and multiples thereof are commonly used as a cushion in determining the extent of threat posed by a particular typhoon, some analysis of the present level of expected error is considered useful.

Two measures of forecast error have been tabulated and recorded. They are:

a. Vector Error: The magnitude of the vector from the forecast position to the corresponding best track position.

b. Right Angle Error: The closest distance from the forecast position to the best track. This may be considered as a measure of track forecasting skill without regard to speed or timing.

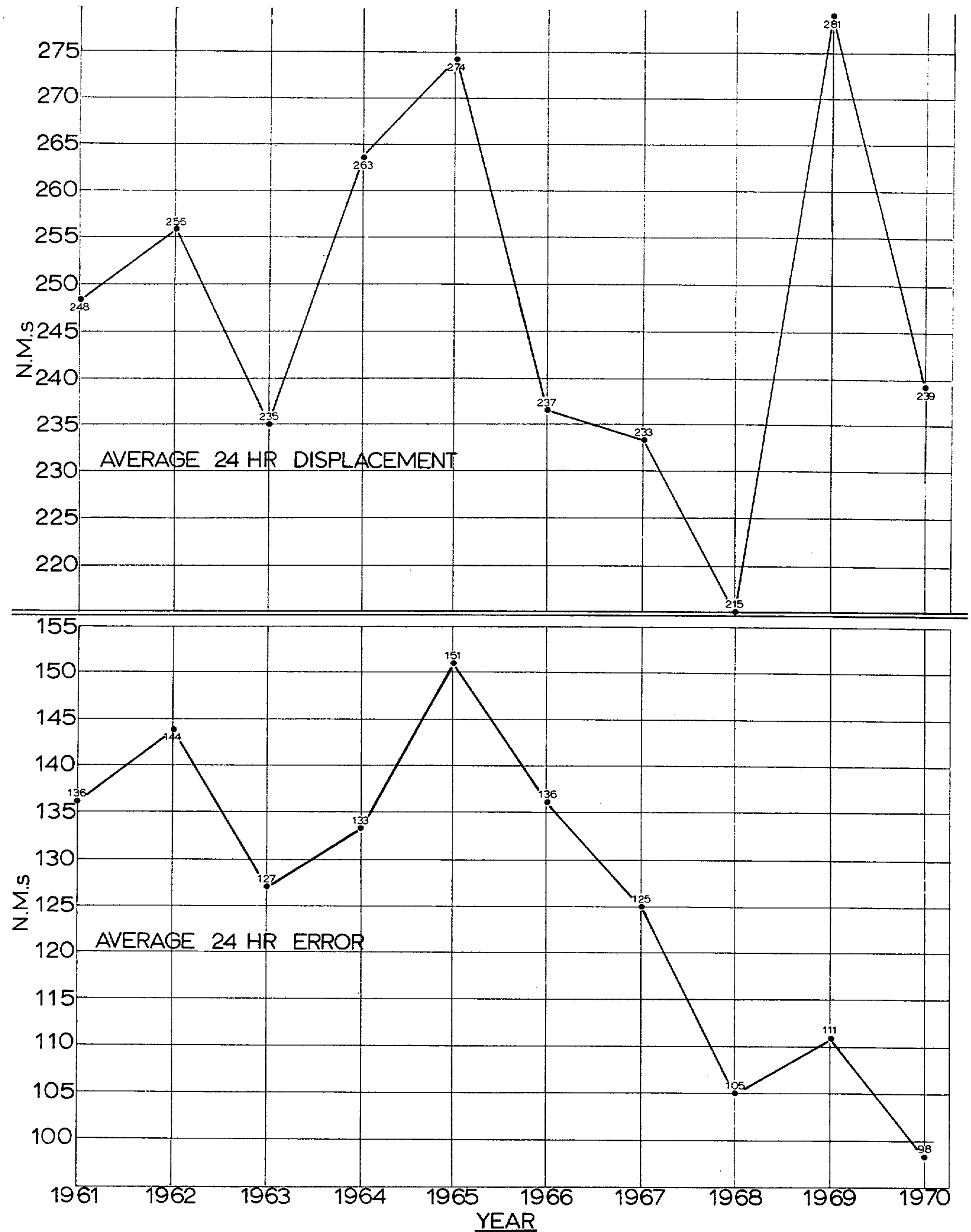
2. 1970 ERRORS:

Figure 4-1 depicts the annual mean vector errors since the 1950's. Figure 4-3 similarly depicts the annual mean right angle errors since 1965. As indicated earlier, both graphs show a gradual downward trend with the means for 1970 singularly less than corresponding means for any other year. In order to make use of this information it is necessary to ascertain the representativeness of the 1970 means as an indicator of the level of expected errors. There are two aspects of the 1970 typhoon season that cast doubt on its representativeness; first, 1970 had a record low number of typhoons and thus overtaxed neither the forecasting/analysis assets at JTWC nor the supporting reconnaissance assets, and secondly, 1970 was not characterized by difficult typhoons to forecast. There was a minimum of recurvatures and hence the rapid accelerating typhoons on a northeast track. There was an abundance of climatological rarities and loops, but this is compensated for by a large portion of relatively straight low latitude tracks.

On balance the errors of 1970 appear to be non-representative of the current capability of the Typhoon Warning Service.

3. MEASURES OF DIFFICULTY

In 1969 (FWC/JTWC, 1969) an attempt was made to gauge the difficulty of a season by normalizing mean error with mean typhoon displacement. Figure 3-1 compares the mean annual



275
270
265
260
255
250
245
240
235
230
225
220
N.M.s
AVERAGE 24 HR DISPLACEMENT
248
256
235
263
274
237
233
215
281
239
155
150
145
140
135
130
125
120
115
110
105
100
N.M.s
AVERAGE 24 HR ERROR
136
144
127
133
151
136
125
105
111
98
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
YEAR

FIGURE 3-1

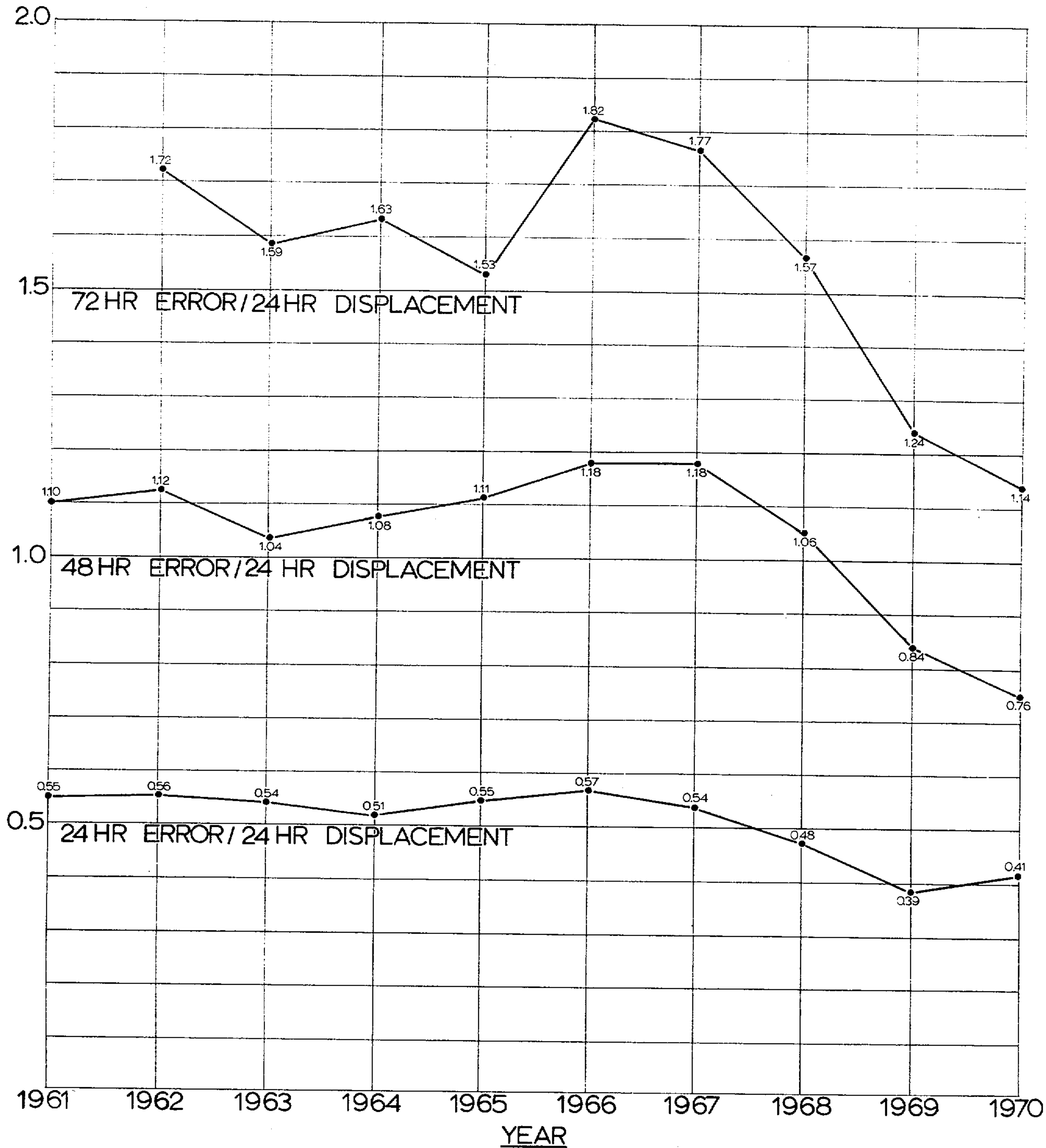

2.0
1.5
1.0
0.5
72 HR ERROR/24 HR DISPLACEMENT
48 HR ERROR/24 HR DISPLACEMENT
24 HR ERROR/24 HR DISPLACEMENT
1.72
1.59
1.63
1.53
1.82
1.77
1.57
1.24
1.14
1.10
1.12
1.04
1.08
1.11
1.18
1.18
1.06
0.84
0.76
0.55
0.56
0.54
0.51
0.55
0.57
0.54
0.48
0.39
0.41
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
YEAR

FIGURE 3-2

24 hour forecast errors to annual mean 24 hour typhoon displacement. The implication here is that as displacement per 24 hours, or speed of movement, increases so does forecast error. The validity of this implication is supported by the remarkable similarity in the two curves. Figure 3-2 presents 24, 48, and 72 hour mean errors normalized by dividing mean error by mean 24 hour displacement. This depiction reveals that little real improvement occurred until 1968 when a modest improvement was initially noted in 24 hour errors as well as the beginning of a dramatic improvement in 48 and 72 hour outlook errors.

Another method of estimating the difficulty of a year (or a forecast) is to normalize the error by the error made by any of the objective techniques.

The 1969 Annual Typhoon Report (FWC/JTWC, 1969) suggested using an objective extrapolation as the normalizing vehicle. Unfortunately a homogeneous comparison of extrapolative errors versus official errors is available only for 1968, -69, and -70, thus prohibiting a long term comparison of errors normalized in this fashion.

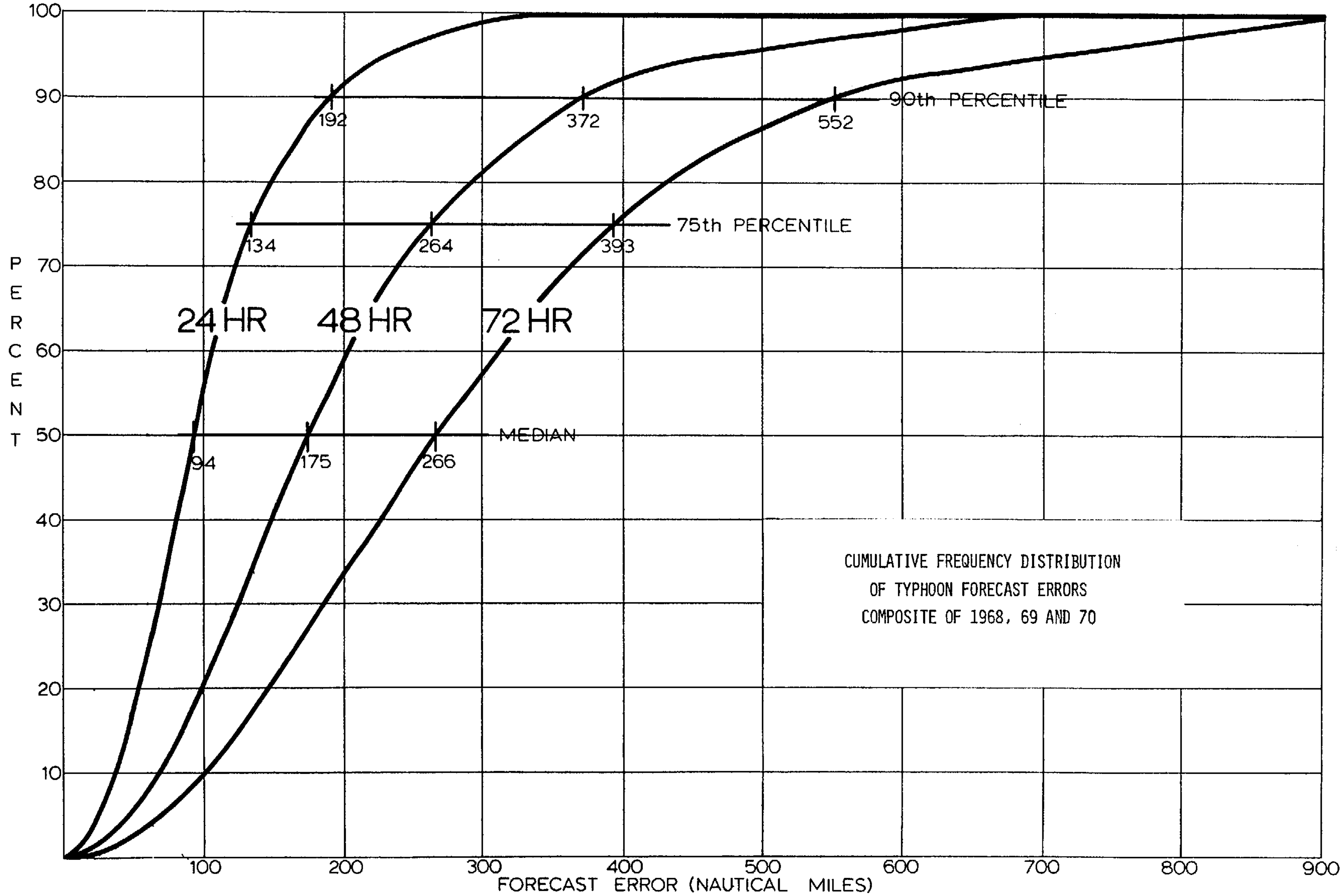
	1968	1969	1970
EXTRAPOLATION ERROR (N.M.)	108	131	121
OFFICIAL ERROR (N.M.)	103	121	103
NORMALIZED ERROR (%)	95.2	92.2	85.1

4. A SUGGESTED ERROR STANDARD

It is considered that a conservative estimate of the present level of forecasting capability can be made by combining the forecast errors made over the past three years which includes the period of apparent improved capability depicted in Figure 3-2.

Figure 3-3 is a cumulative frequency distribution of composited 1968, -69, and -70 forecast errors at 24, 48, and 72 hours. From this presentation an estimate of error confidence limits or percentiles can be deduced.

Mean vector and right angle or track errors for this combined period are given in Table 3-3.



CUMULATIVE FREQUENCY DISTRIBUTION
OF TYPHOON FORECAST ERRORS
COMPOSITE OF 1968, 69 AND 70
PERCENT
FORECAST ERROR (NAUTICAL MILES)
24 HR
48 HR
72 HR
90th PERCENTILE
75th PERCENTILE
MEDIAN
192
372
552
134
264
393
94
175
266

FIGURE 3-3

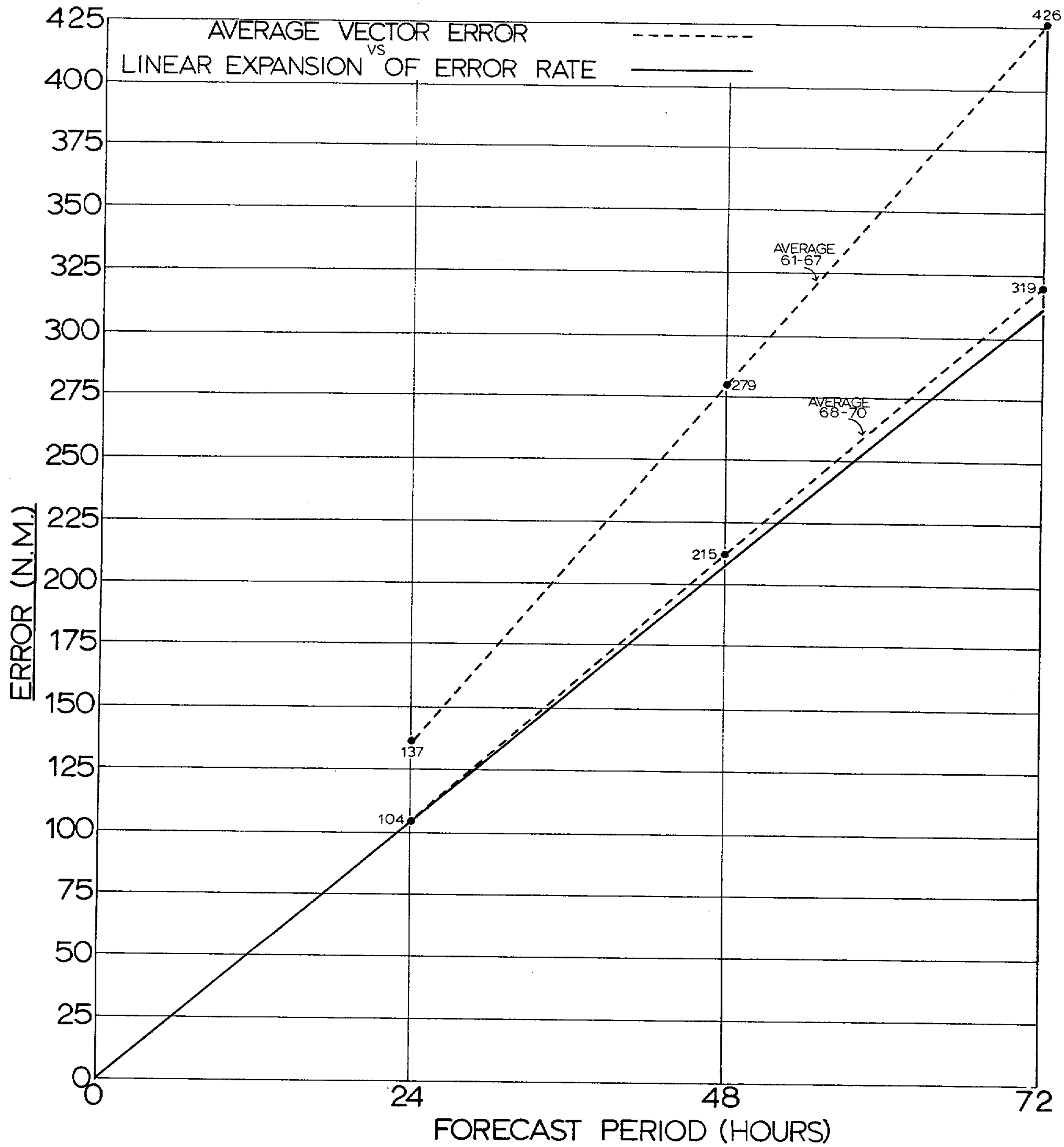

AVERAGE VECTOR ERROR
VS
LINEAR EXPANSION OF ERROR RATE
ERROR (N.M.)
FORECAST PERIOD (HOURS)
AVERAGE 61-67
AVERAGE 68-70
426
319
279
215
137
104
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
375
400
425
0
24
48
72

FIGURE 3-4

	MEAN Vector Error	MEAN Track Error
24 Hour	104 N.M.	64 N.M.
48 Hour	215 N.M.	131 N.M.
72 Hour	319 N.M.	200 N.M.

Composite mean errors for 1968 through 1970.

TABLE 3-3

A comparison of the means of Table 3-3 with the cumulative frequency distribution curves of Figure 3-3 indicate that the mean errors approximate the 60% confidence level. This combined period is considered to be representative of the present level of capability of typhoon forecasting.

Figure 3-4 compares the average errors for the period 1968-70 with those of 1961-67. This comparison reveals an average error reduction of about 25% or some 34 miles per 24 hour forecast interval. Figure 3-4 also illustrates the near linear expansion of forecast error with time. It is considered unlikely that a sub-linear expansion of errors can be achieved because the nature of forecast techniques tends to compound errors in the time-step process.

5. THE FUTURE

There are no dramatic schemes pending which would lead to significant reduction in forecast errors. There is some expectation that some of the larger errors can be reduced by judicious application of climatological probabilities. Simpson (1971) has indicated that Atlantic hurricane forecasts are kept within the HURRAN 50% probability ellipses. This would probably tend to reduce the large error cases. Such ellipses are output by the similar Pacific TYFOON program (Jarrell and Somervell, 1970) and this will be used in much the same way (although not likely as a hard and fast rule).

C. CLASSIC EXAMPLE OF FUJIWHARA INTERACTION

During early September 1970 tropical storms Ellen and Fran provided many anxious moments for the forecasters at JTWC and for the people on Okinawa because of their apparently strange and definitely unpredictable behavior. In fact, the forecast errors on Ellen and Fran were the highest of all the 1970 named storms. (See error statistics, Chapter 4.) After the dust had settled and their respective tracks were superimposed in post analysis it became evident that the explanation of their fickle maneuvers lies mainly in an extreme interaction between the two vortices a la Fujiwhara (1921 and 1923).

The best tracks of the two cyclones are depicted in Figure 3-5. The intersection of the tracks is southern Okinawa. Ellen passed across the island first followed by Fran some 15 hours later. Both tracks were well documented by numerous aerial reconnaissance and land radar fixes during most of their life time. Neither storm ever became very strong. Ellen hit a maximum of 45 knot sustained winds at point 5 on the best track and weakened thereafter. Fran attained 50 knot maximum sustained winds at point 4 on the best track and maintained this intensity through point 8.

To obtain the most vivid depiction of the interaction of the storm pair the steering flow was subtracted from the resultant movement in order to show the motion of the two relative to each other. The steering flow was assumed to be reflected by the track of the computed centers of rotation of the cyclone pair. A weighted center of rotation (center of mass) was located along the axis connecting the two storms at six hourly intervals using the following equation as suggested by Brand (1968):

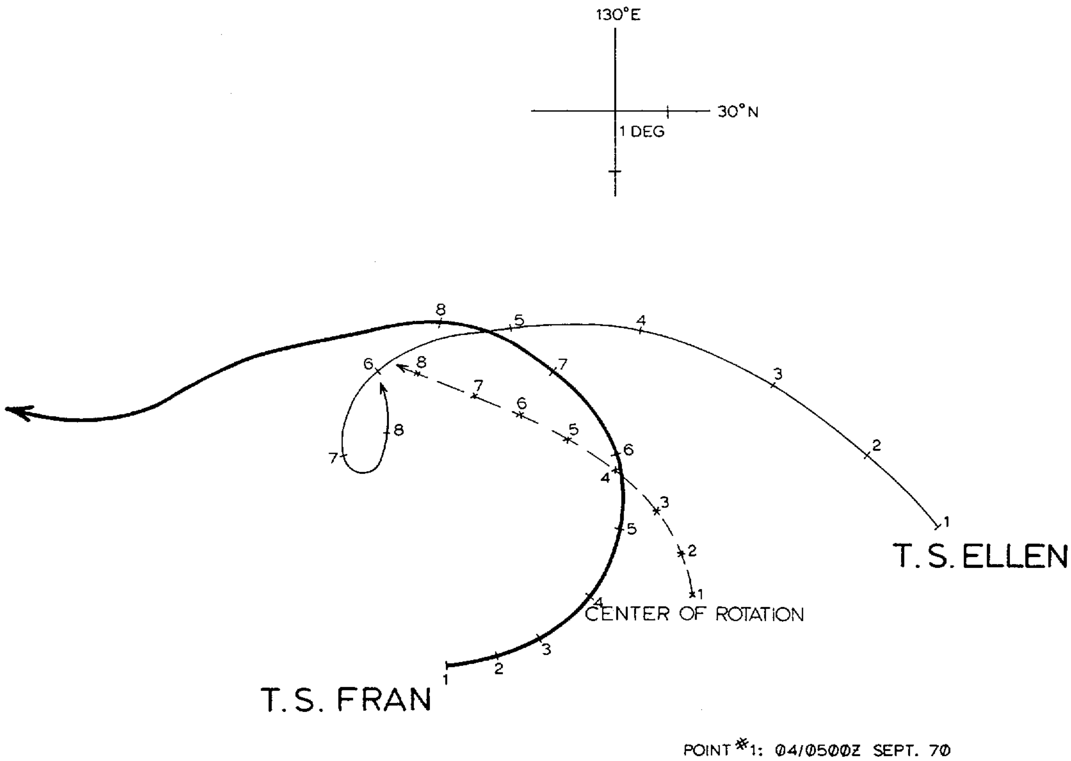
$$d_1 = \frac{DV_2}{V_1+V_2}$$

where

- d_1 is the distance to the center of rotation from cyclone 1
- D is the total separation distance of the two cyclones
- V_2 is the maximum wind speed of cyclone 2
- V_1 is the maximum wind speed of cyclone 1

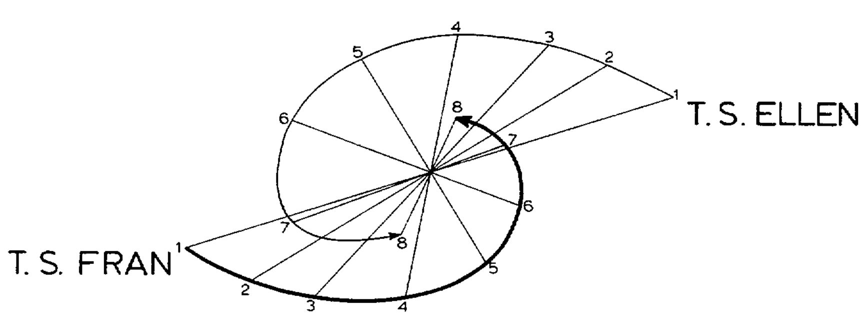
The resultant track of the centers of rotation is shown as the dashed line in Figure 3-5. In general the track is

FUJIWHARA INTERACTION



BEST TRACKS (6 HOURLY POSITS)

FIGURE 3-5



RELATIVE MOTION

FIGURE 3-6

northwesterly at 10 knots, with some cyclonic curvature. This agrees closely with observed middle level steering during this period.

After subtracting this steering flow from the resultant movement of each storm the relative motion of the cyclone pair shows the interaction quite dramatically as can be seen in Figure 3-6. Riehl (1954) made a similar plot for a 1945 typhoon pair. See his Figure 11.44 for comparison.

The interaction of Ellen and Fran was a classic example of the Fujiwhara effect. In simple terms this effect can be explained as follows: When two cyclones are close enough to interact, the relative motion of the two is manifest in cyclonically convergent paths wherein the rate of rotation increases as the distance between the two storms decreases. During the 42 hours of interaction between Ellen and Fran, depicted in Figure 3-6, the two storms cyclonically rotated 220° about each other and converged from a distance 450 N.M. apart at point 1 to 140 N.M. at point 8. In reality, the effect was observed to have progressed even further with the likely possibility that Ellen was completely absorbed near the center of Fran. The last fix on Ellen was made at 06/0130Z, two and one half hours after point 8, at which time she was about 30 N.M. from the center of Fran at a location denoting a total rotation of 280° from the beginning of their interaction.

Brand (1968) plotted the 12-hour angular changes of binary systems versus the average separation distance between them during the period for numerous cases. He found a good correlation in support of the theory. See his Figure 2. Similar changes for the Ellen-Fran pair follow:

12 Hr Interval Between Points	Angular Change	Average Separation Distance
1-3	+31°	430 N.M.
3-5	+71°	290 N.M.
5-7	+80°	260 N.M.

These values plotted on the graph in his Figure 2 closely fit the regression equation computed from his data.

In retrospect, one notes a clear cut case of irony in the Ellen-Fran episode. Even though the data indicate that the Ellen and Fran interaction to be, to our knowledge, the most extensive example of the Fujiwhara effect ever documented, nevertheless it was unrecognizable during most of the period it was occurring.

D. AN EVALUATION OF AERIAL RECONNAISSANCE FIX ACCURACIES

1. INTRODUCTION:

The Joint Typhoon Warning Center (JTWC), in the course of following tropical cyclones, is dependent on aerial reconnaissance fixes. These include penetration fixes near the surface (usually done by the Navy's VW-1) and at the 700 mb level (normally done by the USAF's 54WRS) and aircraft radar fixes taken from outside the eye. It is helpful for the typhoon duty officer to have some idea of relative fix accuracy. Since most methods of predicting typhoon motion depend on the cyclone's movement during the previous 12 hours, "In some instances an error of as little as 10-15 degrees in computed direction of vortex motion based upon the position 12 hours previous and the present location can produce variations in the predicted displacement of 75-100 miles in 24 hours and 400 miles in 72 hours," (Simpson, 1971). Diagnoses are presented that compare deviations of penetration versus radar fixes and surface versus 700 mb level penetration fixes from the post-analyses best track (BT) as a reference. A further comparison is made between deviations right and left of BT at both the 700 mb level and the surface.

2. PROCEDURES:

A total of 911 fixes were used: 235 by surface penetration, 446 by 700 mb penetration, and 230 by radar. Table 3-4 gives a summary of the data.

SUMMARY OF DATA USED

Surface fixes (1967 through T. Georgia, 1970)	235
700 mb fixes (1967 through T. Georgia, 1970)	446
Total penetration fixes	681
Total radar fixes (1967-1969)	230
Total fixes used	911

TABLE 3-4

Fix deviations from BT were measured at right angles in nautical miles. Data were taken only from the time the storm reached 64 kts or greater to the time it degenerated to less than 64 kts.

Mention should be made of possible errors that exist in the data. It should be understood that the BT is a subjectively drawn track. Best Track Officers change from year to year and a bias possibly arises as one best tracker may give more emphasis to a fix of one type/level over another. It should be expected that, by using nearly four years of data, this bias has been minimized.

Nonrepresentative comparisons might also be introduced when a storm moves erratically since the best track is heavily smoothed in these situations. Therefore, areas of extreme track curvature and loops were neglected and those fix data were not considered.

Three comparisons were made, as listed below:

(1) The magnitude of deviations from BT at the surface and at 700 mb level were compared.

(2) The magnitude of deviation from BT of all penetration and radar fixes were compared.

(3) Comparisons between deviations to the right and to the left of BT at the surface and at the 700 mb level were made.

Statistical tabulations of the data used in each study are shown in Tables 3-5 and 3-6.

DEVIATION FROM BEST TRACK

CLASS INTERVAL	FREQUENCY OF FIXES			
(N.M.)	SURFACE	700MB	ALL PENETRATIONS	RADAR FIXES
0- 2.9	107	221	328	86
3- 6.9	70	138	208	49
7-10.9	24	38	62	35
11-14.9	13	29	42	26
15-18.9	12	10	22	9
19-22.9	2	6	8	19
23-26.9	5	2	7	3
27-30.9	0	1	1	0
31-34.9	1	0	1	2
35-38.9	0	0	0	0
39-42.9	0	1	1	0
43-46.9	1	0	1	0
55-58.9	0	0	0	1
MEAN (N.M.)	5.72	4.84	5.14	7.73

TABLE 3-5

DEVIATION LEFT AND RIGHT OF BEST TRACK
FREQUENCY OF FIXES

DEVIATION FROM BEST TRACK (N.M.)	SURFACE		700 MB	
	LEFT	RIGHT	LEFT	RIGHT
2- 4	37	42	73	80
6- 8	19	26	52	42
10-12	7	7	11	12
14-16	5	8	14	10
18-20	3	5	3	2
22-24	1	4	3	2
26-28	0	0	0	0
30-32	0	0	0	1
34-36	1	0	0	0
38-40	0	0	1	0
42-44	1	0	0	0
MEAN (N.M.)	7.49	7.52	6.87	6.25

TABLE 3-6

3. RESULTS:

A summary of statistical results of the study is contained in Table 3-7.

SUMMARY OF RESULTS OF STUDY

Mean Deviation from Best Track		
Radar	7.73 N.M.	
Penetration	5.14 N.M.	
Mean Deviation from Best Track		
Surface	5.72 N.M.	
700 mb	4.84 N.M.	
Mean Right and Left Deviation from Best Track		
Surface	Left of Best Track	7.49 N.M.
	Right of Best Track	7.52 N.M.
700 mb	Left of Best Track	6.87 N.M.
	Right of Best Track	6.25 N.M.

TABLE 3-7

Comparing first the accuracies of total penetrations against those fixes made by radar, it can be seen that the mean deviation of radar fixes from BT was greater than that for all penetrations (surface plus 700 mb fixes) by 2.59 N.M. The statistical significance of these results were tested using the χ^2 test. Making the assumption that the radar fixes were a sample of the population (penetrations), it was found that at the .01 and .05 levels of confidence, the radar fixes were not representative of that population.

This same approach was used in comparing the surface fixes and 700 mb fixes. The surface fixes deviated more from BT than the 700 mb fixes by 0.88 N.M. Since there was nearly twice as many upper level fixes (446 at 700 mb and 235 at the surface), the 700 mb fixes were assumed to be the population. At both levels of confidence, .01 and .05, the surface fixes were statistically unrepresentative of the assumed population.

Comparing the mean deviations right and left of BT, it can be seen that there was virtually no difference (0.03 N.M.) at the surface. The 0.03 N.M. bias was to the right of BT. At the upper level, however, there was just over a half a mile (0.62 N.M.) greater mean deviation to the left of BT.

A probability test was used in both the above comparisons. At the surface and 700 mb level, it was hypothesized that there was an equal chance that the fixes would occur on either side of BT. The results (at both the .05 and .01 levels of confidence) indicated that this could be true--that there may have been an even probability that a fix could occur on either side of BT at either level, and the difference in means occurred by chance.

4. CONCLUSIONS:

If one regarded the plotted BT as representative of the mean path of the storm, then it appears that the radar fixes show a greater deviation than aircraft penetrations.

Figure 3-7 was constructed to show the cumulative percentage of fixes for penetrations and radar fixes as a function of deviation from BT. For instance, fifty percent of the penetrations are within ±3 N.M. of BT as compared to ±5 N.M. of BT for radar fixes. The greater deviation of an aircraft radar fix is not surprising as ranging and azimuth errors within the radar coupled with beam width distortion of the target must also be combined with possible navigation error of aircraft position (see Jordan, 1963 and Holliday, 1966). In updating typhoon position, the forecaster should note these accuracy statistics for considering possible biases in past motion that could affect his projected track. Results of this study also show that surface fixes

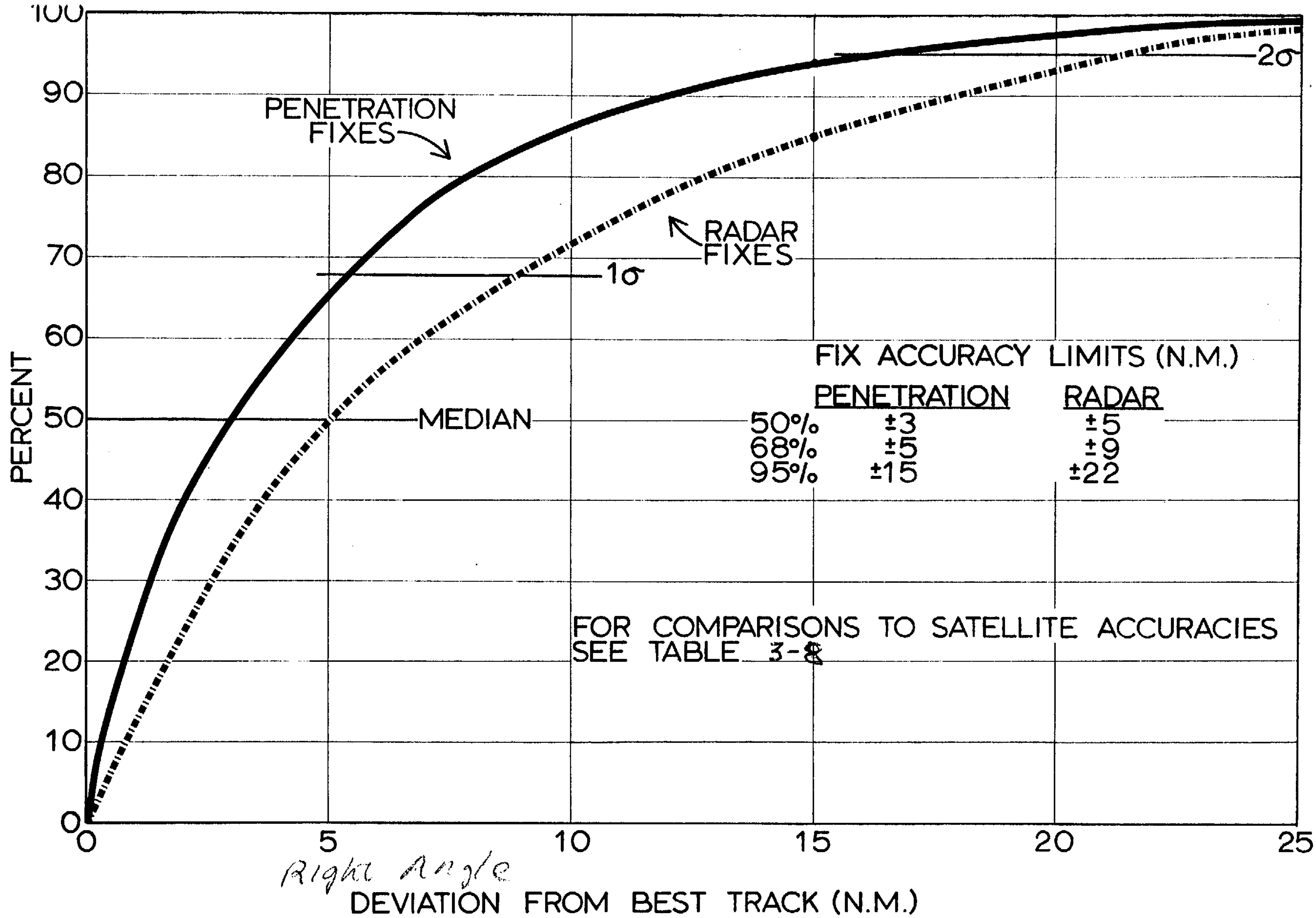

PERCENT
100
90
80
70
60
50
40
30
20
10
0
PENETRATION FIXES
RADAR FIXES
1σ
2σ
MEDIAN
FIX ACCURACY LIMITS (N.M.)
PENETRATION RADAR
50% ±3 ±5
68% ±5 ±9
95% ±15 ±22
FOR COMPARISONS TO SATELLITE ACCURACIES SEE TABLE 3-8
0 5 10 15 20 25
Right Angle
DEVIATION FROM BEST TRACK (N.M.)

FIGURE 3-7

deviate more than the upper level (700 mb) fixes. These measured deviations from the mean path (BT) could possibly be a function of fix accuracy (navigation), discontinuity of parameters measured to determine fix location, and physical abnormalities such as transitory changes to storm structure and internal oscillatory motions. Since the data indicate the lower position of the storm shows more deviation than the middle level, it is quite possible either one or more of these influences decrease with altitude. More data need to be gathered in this area; unfortunately, no multi-aircraft penetrations are available in Pacific typhoons.

Attempting to summarize the data relative to right and left deviation is difficult. If the deviations are considered significant, there appears to be a slope within the lower portion of the typhoon (surface to 700 mb). This may be an influence of cases in the population which are near a more baroclinic environment or have been influenced by terrain such as passage of the Philippine Islands where the vertical profile is disrupted. This is not to imply there is a slope in the wall cloud but a difference in location of centers (i.e. cloud, wind and pressure centers) within the eye. If this slope does exist, it appears that it is from right to left with height relative to its direction of movement.

Three points in summary are noted: (1) radar fixes show a greater deviation than penetration fixes; (2) surface fixes appear to deviate more than 700 mb fixes, however, data are inconclusive; and (3) there is a suggestion of a vertical slope to the typhoon center, if only transitory, toward the left relative to the storm's movement.

E. MISCELLANEOUS SATELLITE BULLETIN (MSB) DATA

The Analysis Branch of NESS at Suitland, Maryland reviews daily Advanced Vidicon Camera System (AVCS) pictures for surveillance of tropical disturbances. (Pictures are stored with readout at a Command Data Acquisition Station then microwaved to NESS.) Upon detection, a bulletin is issued based on a description system of stages and categories of development. A total of 150 MSB's on tropical systems was issued for the Central and Western Pacific during 1970 as depicted in ESSA-9 and later ITOS-1 satellite pictures.

Verification of the position and intensity indicated by the MSB's was made on named storms in WESTPAC based on best tracks prepared at JTWC. Data were stratified by stage (Dvorak, 1968) and further classified into category intervals for intensity verification (Hubert and Timchalk, 1969).

Verification summation data are presented in Table 3-8.

MSB VERIFICATION VS. JTWC BEST TRACK

POSITION (all tropical storm tracks)

RIGHT ANGLE ERROR (N.M.)

Stage	B	C	C+	X
Cases	27	15	10	80
Mean	33	25	23	24
Standard Deviation	35	23	21	20

VECTOR ERROR (N.M.)

Stage	B	C	C+	X
Cases	27	15	10	80
Mean	66	52	71	39
Standard Deviation	60	30	63	25

INTENSITY ERRORS (KTS) (typhoon tracks)

	ALL				CATEGORY X				
Stage	B	C	C+	X	2	2.5	3.0	3.5	4
Cases	5	4	4	75	20	7	21	7	20
Algebraic Mean	-11	-14	-11	-8	-1	-7	-13	-14	-7
Absolute Mean	11	14	16	14	12	20	16	23	11
Standard Deviation	11	10	16	17	14	25	14	24	13

TABLE 3-8

F. NOTE ON OPTIMUM ALTITUDE FOR RECON OF TROPICAL DISTURBANCES

The utilization of APT from meteorological satellites over the past five years at FWC/JTWC Guam has been a significant tool in monitoring the vast data-void areas of the West Pacific for initial detection of tropical cyclones. The daily satellite view affords early surveillance of convective systems which may eventually act as a potential storm embryo.

The indication of a development tendency in the cloud pattern from the satellite picture has allowed early aircraft investigation of the suspect area often before the disturbance has reached the depression category. At this early stage, the perturbation is usually weakly defined in both surface wind and pressure fields since much of the relative vorticity is expressed in terms of cyclonic horizontal shear while the pressure gradient is relatively weak except in the disturbance's northern periphery. Due to the lack of identifiable pattern at this stage, the standard low level investigative (500-1500 ft.) often encounters difficulty describing significant features in the wind and pressure fields that can mark the system as an entity.

The task which faces the typhoon forecaster is to identify and determine a synoptic feature which may tab or tag the state of development of these suspect tropical disturbances and use this to monitor its continuity for signs of further intensification. It would therefore be advantageous that the most descriptive information on the system be provided by the investigating aircraft.

A study prepared by Williams(1970) conducted on the occurrence of cloud clusters in the West Pacific (October 1966-October 1968) showed a distinguishing feature in vertical profiles of relative vorticity at cluster centers between the pre-storm and non-developing types (Figure 3-8). A distinct maximum of relative vorticity was shown for the pre-storm cluster occurring at the 700-500 mb interval.

Since vorticity is expressed mostly in terms of curvature in this layer of the trades (due to the decrease in strength of the basic flow with height; see LaSeur, 1966) it would be likely from the peak of relative vorticity noted by Williams that a marked curvature would be present and also a tendency for a circulation to first form in this layer. The classic model set forth by Riehl (1954) of the wave in the easterlies shows a distinct curvature appearing between the 850-500 mb layer with the existence of a closed vortex at 15,000 feet. Evidence that the maximum amplitude of Atlantic wave disturbances occurs between 5000-15000 feet has also been well documented by Frank (1969).

VERTICAL PROFILES OF 4°-SQUARE AREA

AVERAGE RELATIVE VORTICITY AT CLUSTER CENTERS

(From Atmospheric Science Paper No. 161, Colorado State University, Williams, 1970)

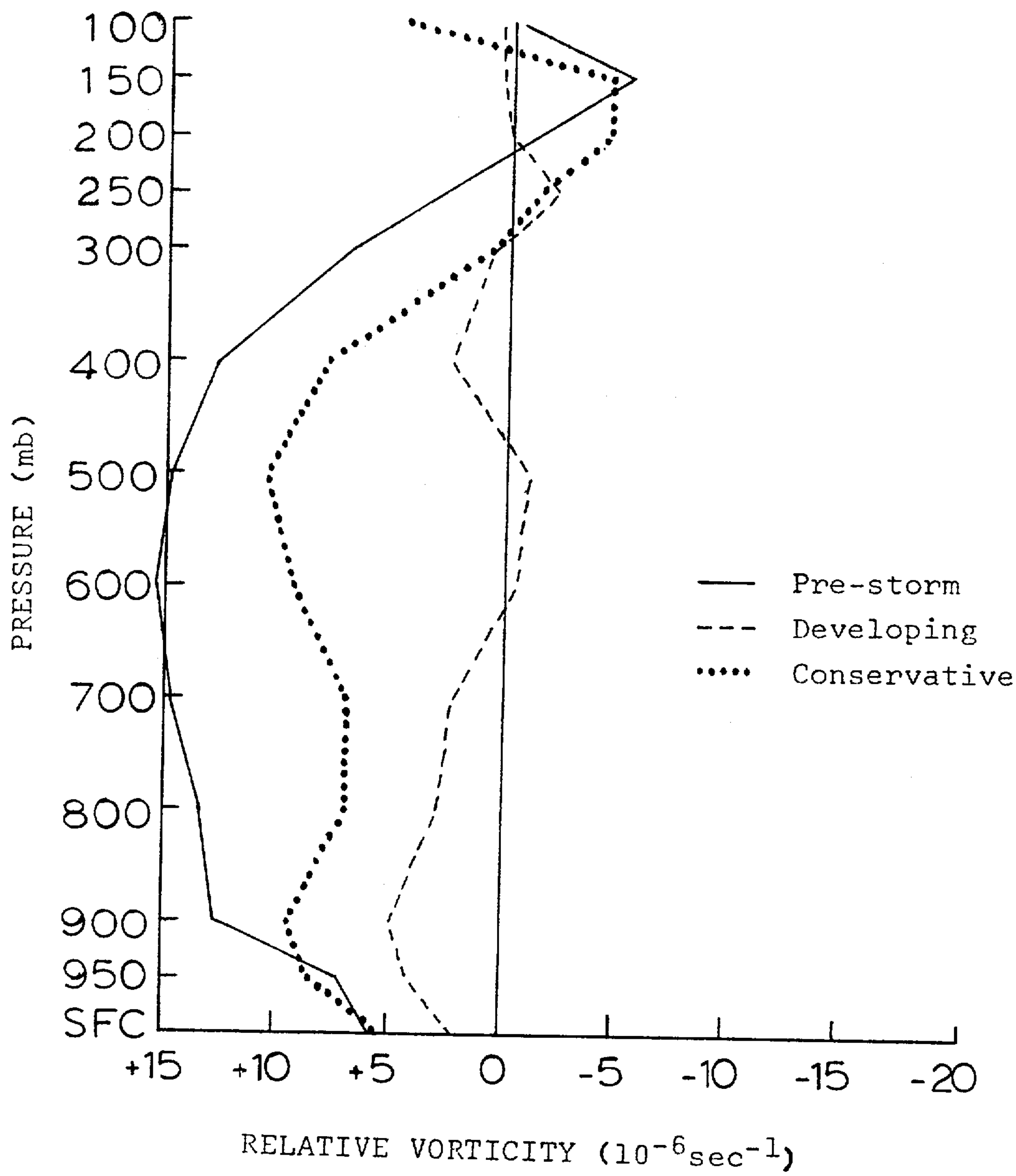


FIGURE 3-8

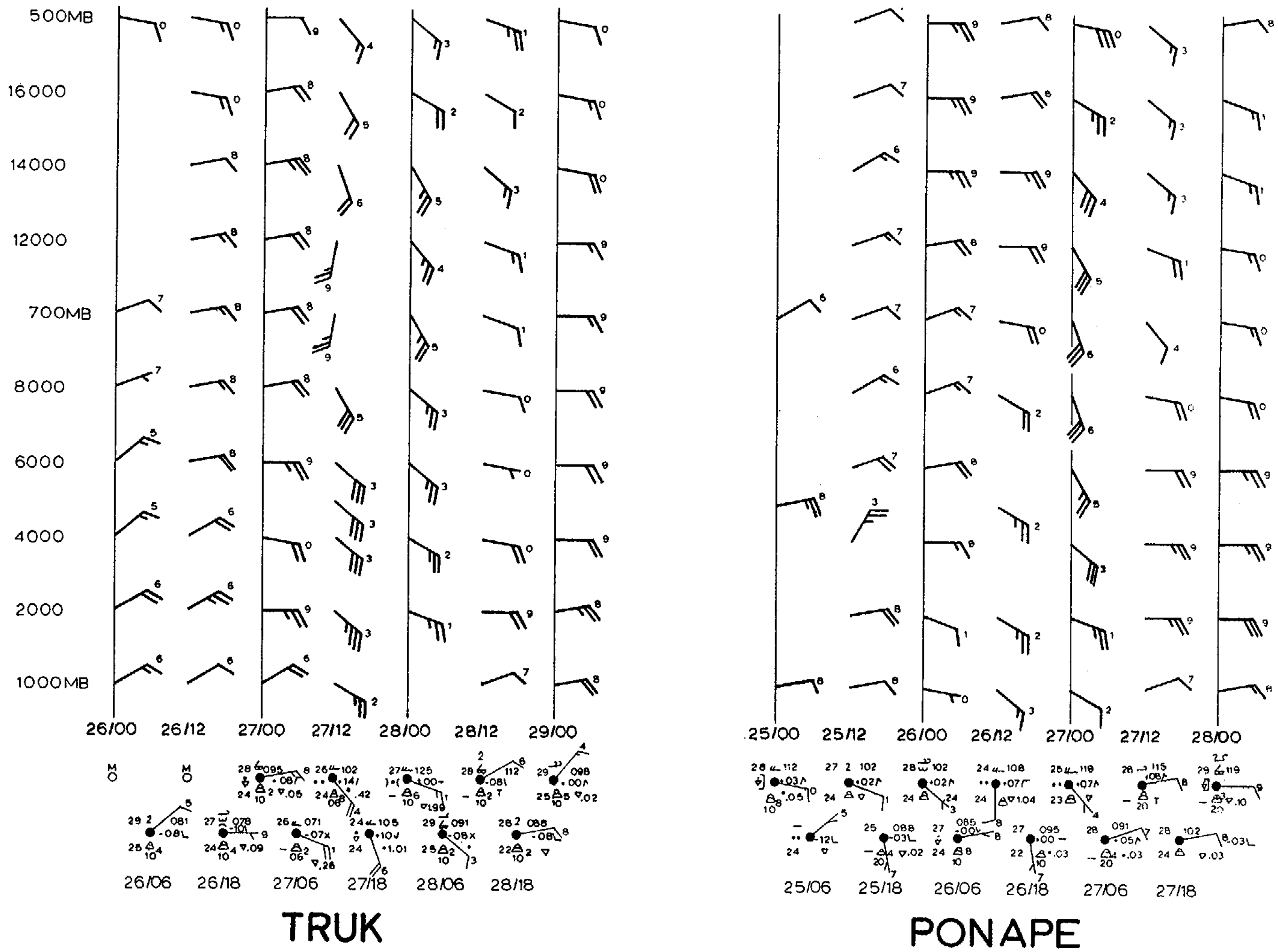
An example for illustration in the West Pacific would be the pre-storm disturbance passing through the Central Caroline Islands during late June 1970. Its early track placed it within the rawinsonde network of the Trust Territories giving an early view of its wind distribution in the vertical. The disturbance initially appeared as a cloud cluster system in the Marshalls on the 24th, tracked westward at 15 kts and moved into the Central Carolines on the 26th with satellite views depicting an extensive increase in convective activity by this time.

The time cross section for Ponape Island's rawin indicated a strong cyclonic shift from 6000-14000 feet between the period 26/00Z and 27/00Z with passage of the perturbation (Figure 3-9). Later Truk (360 N.M. east of Ponape) showed an increase in amplitude of the system as a sharp shift at 10-12,000 feet to a westerly component was detected in its rawin. Although it was evident that a vortex had developed in the lower troposphere, surface data in the vicinity indicated only a weak reflection in the wind field and pressure across the area ranged from 1008 to 1010 mb. Satellite DRIR view by this time (Figure 3-10) showed an organized character to the disturbance cloudiness at least of a stage B classification (Dvorak, 1968).

The suspect area was investigated the following morning (28th) by a recon aircraft at low levels (1,500 ft.) southeast of Guam near Satawal Atoll. Circulation at the surface could not be detected after extensive search of the area. However, the presence of a vortex at 700 mb was indicated as the aircraft passed through the disturbance and encountered a wind shift at this altitude before returning to Guam. With exception of a band of strong easterlies in the system's northern region, the pre-storm system remained weakly reflected in the surface wind field while a flat pressure gradient existed in the general area with values ranging from 1005 to 1007 mb (Figure 3-11). The cloud pattern depicted by the afternoon satellite view revealed a continued organized pattern appearing close to a stage C classification (Figure 3-12).

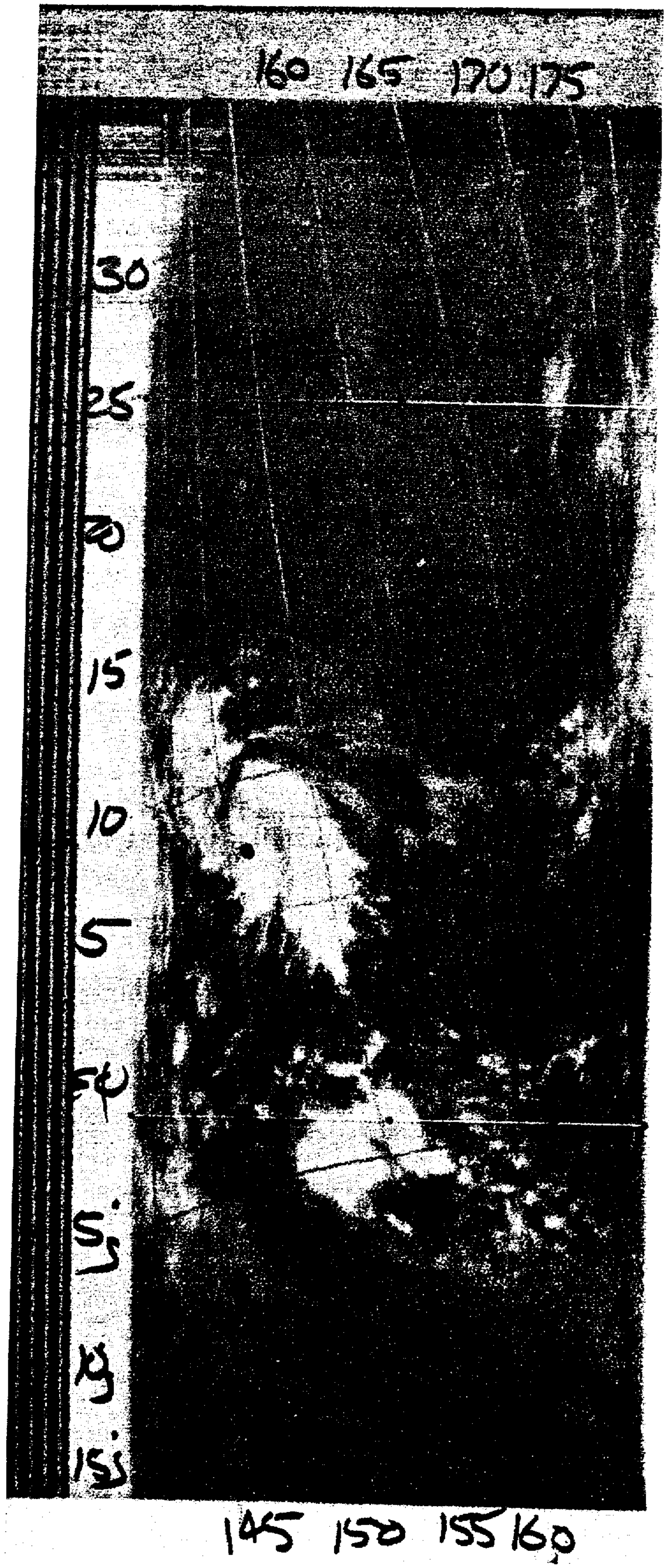
The disturbance passed south of Guam that evening with a follow up aircraft locating Tropical Storm Olga the following morning (29th) north of Ulithi Island with a definite surface circulation, a forming wall cloud, and a 993 mb central pressure.

A complete recon investigation at the 700 mb level the previous day probably would have enabled the detection of a clear-cut perturbation in the wind field providing a more meaningful description of the potential storm embryo than could have been determined from the low level investigation.



TIME CROSS SECTIONS OF RAWIN PROFILES
FOR TRUK AND PONAPE ISLANDS DURING
PASSAGE OF THE PRE-OLGA DISTURBANCE
LATE JUNE 1970

FIGURE 3-9



NIMBUS III DIRECT READOUT INFRA-RED (DRIR)
27 JUNE 1970 1247GMT

(Dot in Cloud Mass is Approximate Location of Truk Island.)

FIGURE 3-10

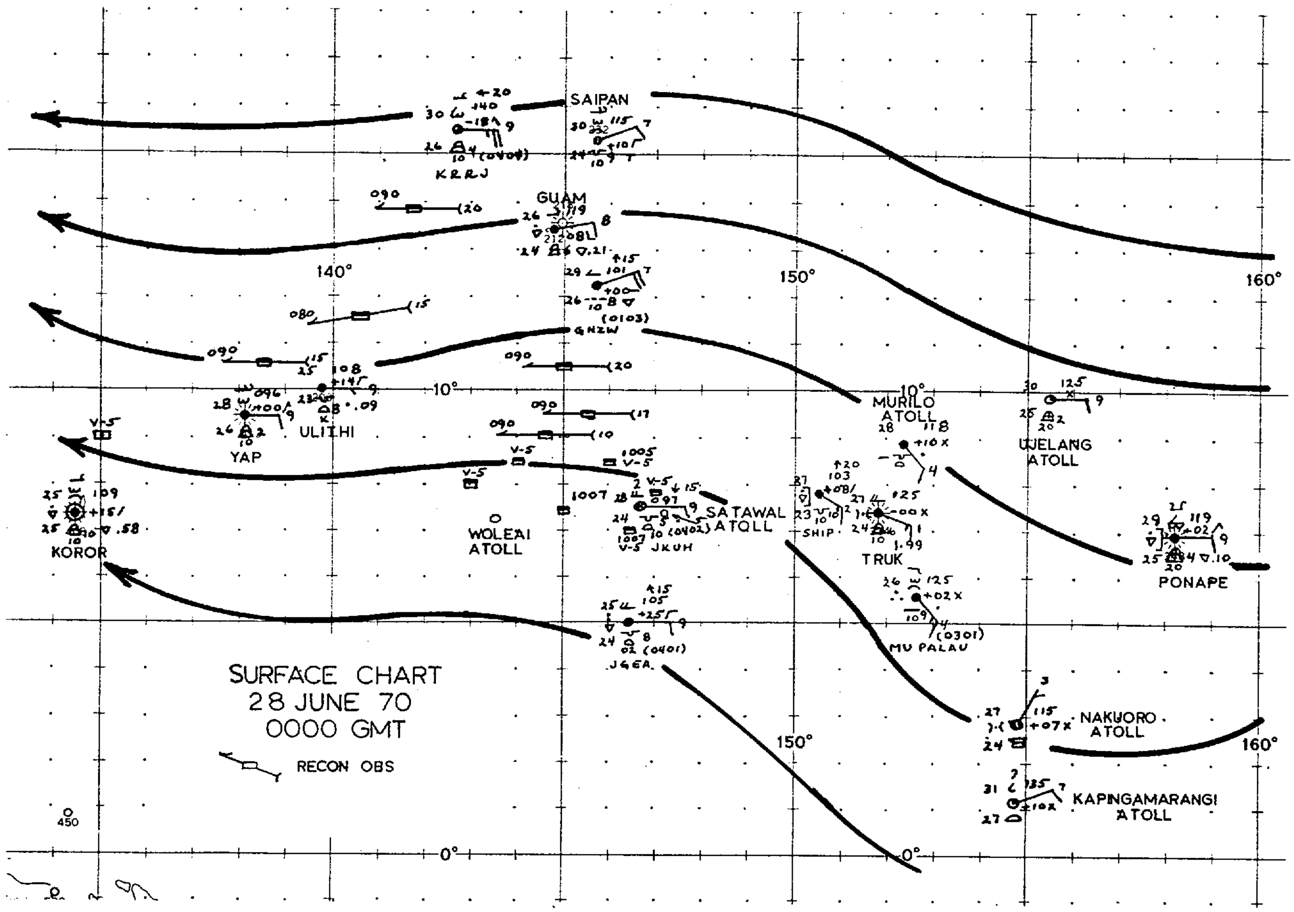
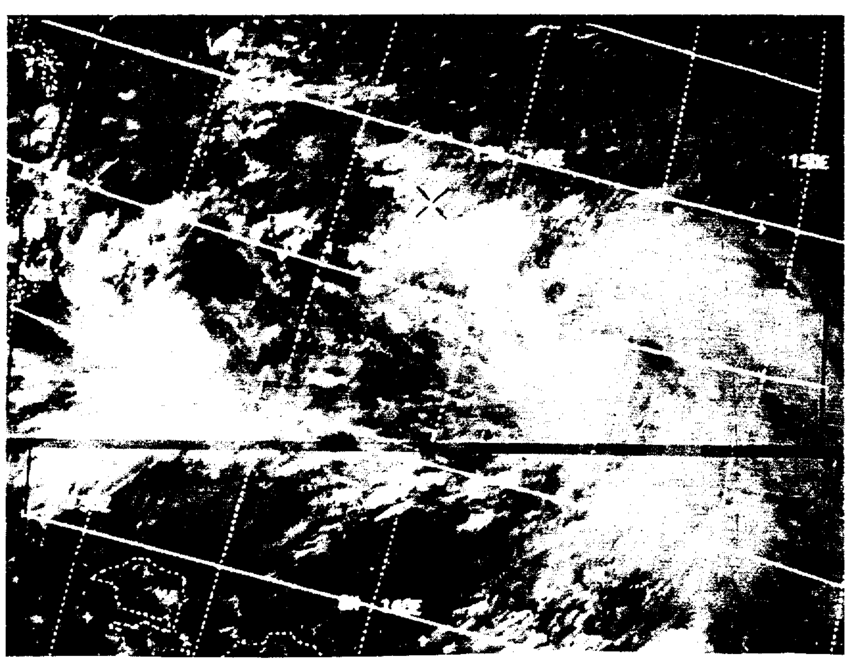


FIGURE 3-11



ITOS-1 VIEW OF
PRE-OLGA DISTURBANCE
28 JUNE 1970 0528GMT

FIGURE 3-12

The significance of an intermediate level investigation then is to label a conservative synoptic feature that could be tied to these suspect systems. Thus the forecaster may have some way to best evaluate the disturbance and determine to what state the development process has progressed.

It should be pointed out that the assumption that all significant disturbed weather over tropical oceans can be tied to moving perturbation of the wind field is not valid (see Zipser, 1971 and Simpson et al, 1967). The object of this note is to place emphasis on disturbances suspect of further development and how to best mark the system as an entity by aircraft recon.

The optimum compromise level for recon investigation in the early stages would appear to be the standard 700 mb level.* Several flights were conducted at the 700 mb level during the 1970 season with encouraging results. It is hoped more data will become available during the 1971 season for further evaluation.

*Obviously the low levels must eventually be investigated to provide definite evidence of the birth of a tropical cyclone.

G. TROPICAL CYCLONE INTENSITY VERIFICATION

1. INTRODUCTION:

Intensity forecasting is recognized as one of the more difficult typhoon forecasting problems, yet the literature on the subject is relatively sparce. This is probably due to the overwhelming role played by the prog track which must be good before an intensity forecast is meaningful (regardless of its accuracy) in adapting the typhoon warning to the local forecast. Since track forecasts have gradually improved over the years, the emphasis on intensity has increased.

Prior to 1969 there was no attempt at JTWC to verify forecasts of intensity. The 1969 verification consisted of a comparison of mean intensity errors and the bias in intensity forecasts at various time intervals. This is useful and will be continued for comparison, but it gives equal weight to a given error on a super typhoon and the same error on a minimal tropical storm. In the former case a 20 knot error is of little significance whereas in the latter it would be very important. It is felt that this deficiency can be overcome by describing errors as a fraction of the observed wind; this type verification is presented later.

2. INTENSITY FORECASTING AND VERIFICATION:

As pointed out in Chapter 1 the basic intensity forecasting technique is a linear extrapolation of past rate of intensification subjectively modified by expected conditions along the predicted track (FWC/JTWC, 1969). Thus there are two independent phases of the forecast, the first requires the determination of the current and recent past intensity and the second involves a synoptic evaluation along a predicted track. The errors incurred in the latter are reasonably random; they are caused by track errors, deficiencies in forecasting the environment along the track and lack of adequate methods to relate the predicted environment quantitatively to intensity changes. Progress in improving this aspect of the problem has been slow although some relationships are known. Synoptic conditions for maximum intensity of tropical cyclones were discussed by Miller (1957). The geographical location of the principal feeder band of the storm as determined by radar and satellite is weighted by the NHC, Miami (Simpson, 1971) in assessing development; this has been enhanced by the acquisition of near real time film loops from the ATS III geostationary satellite. These, of course, are not available for WESTPAC. The Navy Weather Research Facility (1970) has developed rules for evaluating the reintensification potential of tropical cyclones which have crossed the Republic of the Philippines and entered the South China Sea.

The problems in linear extrapolation of intensity as a first guess are obvious and relate to difficulty in ascertaining the instantaneous intensity of the storm at two or more recent points along the track. Reconnaissance estimates cloud the issue (Jordan and Fortner 1960 and 1961) since there is a bias introduced by the fact that penetration is necessarily made in the weakest quadrant, also areas of strongest winds are often obscured by clouds and heavy precipitation. To overcome these problems, a wind/pressure relationship is commonly used and the extrapolation is made on minimum pressures rather than maximum winds. Clearly, if one of two estimates of intensity is in error, the rate of intensification will be deduced incorrectly and the forecast intensities will suffer in like manner, but this type error should be random. When both estimates are off by about the same amount in the same direction, the forecasts may be expected to be in error by nearly a constant. This type error might be expected from an inadequate pressure-wind relationship, and a part of the bias evident in 1969-1970 verification can be attributed to this problem. The 1968 Annual Typhoon Report introduced a wind-pressure relationship which was a modification of a similar relationship presented in 1963 by JTWC. During the past two years confidence in that relationship gradually lessened until in mid-1970, it was virtually abandoned altogether. As a result the typhoons of the first half of 1970 were forecast using one relationship and verified against a post-analysis based on a combination of other relationships, mainly the Takahashi equation (1939). As a result, the mean errors for both halves of the year are about the same but the bias diminished significantly in the latter half. (See Table 3-10.) The bias for both halves of 1970 as well as 1969 was consistantly on the low side (under forecasts), that part not explained by the inadequate pressure-wind relationship is largely attributed to the inability of forecasters to anticipate periods of maximum deepening. These surges of deepening are typically of short duration, 12 to 36 hours, and are usually followed by a plateau, so that maximum underforecasting bias (in terms of knots of error per forecast hour) occurs near 24 hours since extrapolation tends to hit the plateau at longer periods.

Table 3-9 compares intensity forecasts of 1970 to 1969.

	ABSOLUTE MEAN ERROR (KTS)					ALGEBRAIC MEAN ERROR (KTS)				
	WARNING	12HR	24HR	48HR	72HR	WARNING	12HR	24HR	48HR	72HR
1969	4.9	9.0	13.7	22.9	30.2	-1.9	-1.4	-4.2	-6.8	-13.3
1970	6.6	12.1	16.7	21.2	21.7	-3.3	-5.3	-8.6	-8.9	-11.0

TABLE 3-9

Notice the apparent degradation in 1970 when a different standard was used for verification than was used for forecasting as opposed to 1969 when the same standard was used throughout.

Table 3-10 compares the first half of 1970 to the last half. (The season is divided after Typhoon Clara which marked the point after which the 1968 relationship was abandoned.)

	ABSOLUTE MEAN ERROR (KTS)					ALGEBRAIC MEAN ERROR (KTS)				
	WARNING	12HR	24HR	48HR	72HR	WARNING	12HR	24HR	48HR	72HR
EARLY 1970	7.7	12.4	16.2	20.0	23.4	-5.3	-8.0	-10.8	-10.2	-18.0
LATE 1970	5.6	11.8	17.2	22.2	20.3	-1.4	-2.7	-6.5	-7.9	-5.4

TABLE 3-10

While no significant difference is apparent in the absolute mean errors, the low side bias was markedly reduced.

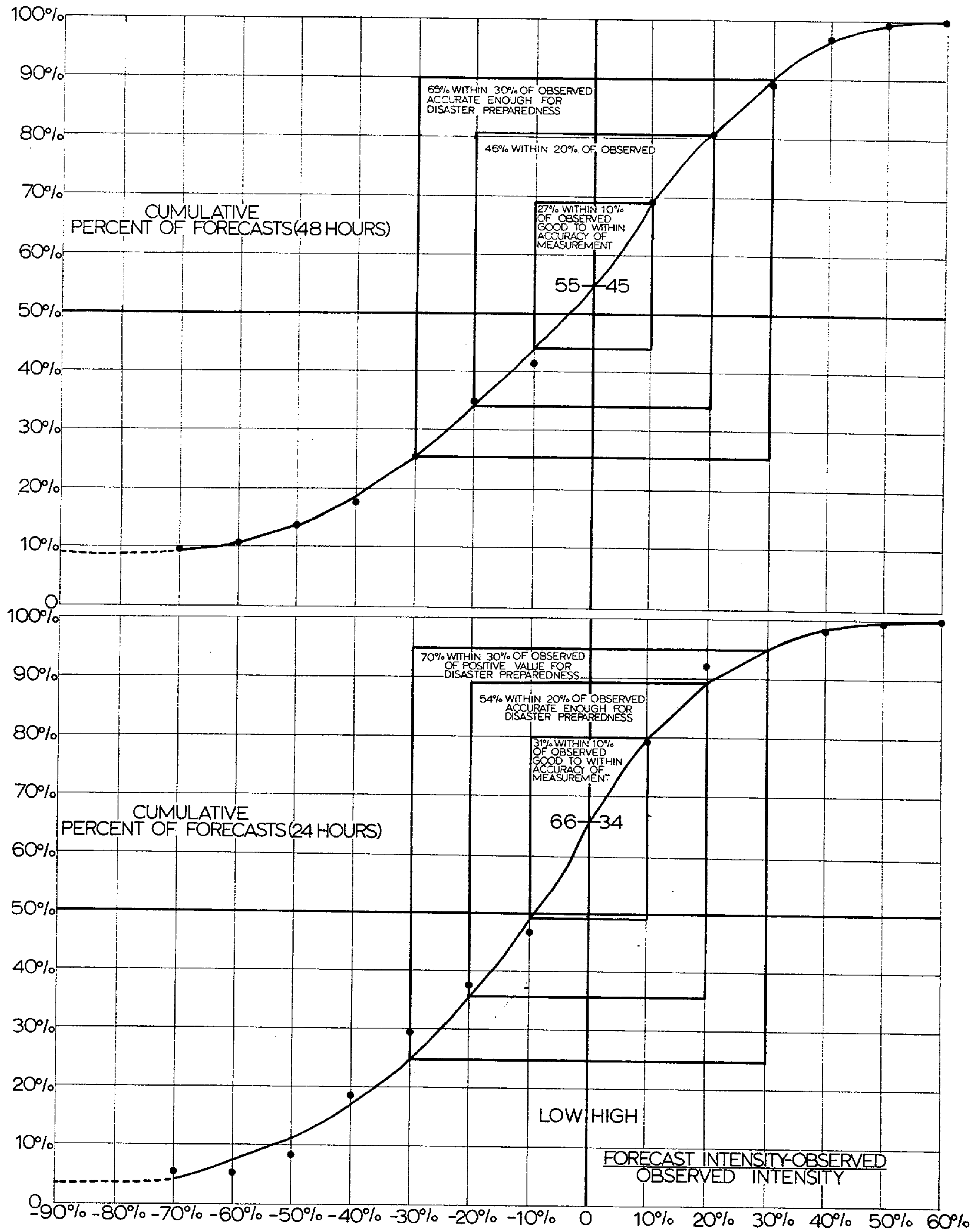
3. A MEASURE OF ACCEPTABILITY:

As mentioned earlier an analysis of intensity errors as a fraction of observed winds was made. This concept implies that as wind speed increases, so does the acceptable error in wind forecasts. With this implication in mind, some acceptability criteria were established (from the viewpoint of adequacy for disaster control planning) as follows:

	12 Or 24 Hours	48 Or 72 Hours
Accurate to within measurement error	Error $\leq$ 10%	Error $\leq$ 10%
Adequate	Error $\leq$ 20%	Error $\leq$ 30%
Useful	Error $\leq$ 30%	Error $\leq$ 40%
Inadequate	Error > 30%	Error > 40%

Note the criteria become less stringent at longer time intervals since changing the degree of readiness is still possible.

Figure 3-13 shows the cumulative distribution of intensity forecast errors as a percent of observed wind for 24 and 48 hours. Envelopes of 10, 20, and 30% errors are shown. Based on Figure 3-13 and above criteria, the distribution of



100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0
65% WITHIN 30% OF OBSERVED ACCURATE ENOUGH FOR DISASTER PREPAREDNESS
46% WITHIN 20% OF OBSERVED
27% WITHIN 10% OF OBSERVED GOOD TO WITHIN ACCURACY OF MEASUREMENT
CUMULATIVE PERCENT OF FORECASTS(48 HOURS)
55 45
70% WITHIN 30% OF OBSERVED OF POSITIVE VALUE FOR DISASTER PREPAREDNESS
54% WITHIN 20% OF OBSERVED ACCURATE ENOUGH FOR DISASTER PREPAREDNESS
31% WITHIN 10% OF OBSERVED GOOD TO WITHIN ACCURACY OF MEASUREMENT
CUMULATIVE PERCENT OF FORECASTS (24 HOURS)
66 34
LOW HIGH
FORECAST INTENSITY-OBSERVED
OBSERVED INTENSITY
-90% -80% -70% -60% -50% -40% -30% -20% -10% 0 10% 20% 30% 40% 50% 60%

FIGURE 3-13

acceptable intensity forecasts during 1970 is as follows:

	24 Hour	48 Hour
Accurate to within measurement error	31%	27%
Adequate	54%	65%
Useful	70%	79%
Inadequate	30%	21%

Notice from Figure 3-13 that these acceptable percentages could be significantly enhanced if the low side bias can be reduced.

4. FUTURE:

A suggestion (FWC/JTWC, 1969) to attempt to improve forecasts by studying cases of gross errors as well as climatological rate of intensification appears valid. Fung (1970) has suggested that the tropical cyclone population tends to show peak occurrence around three minimum pressure values, 970 mb, 940 mb, and 915 mb. This work and a climatology of super typhoons (FWC/JTWC, 1970) imply favored seasons and geographical locations for occurrences of tropical cyclones within these intensity categories, thus some improvement in intensity forecasting might be realized by an applied climatological approach to forecasting. Further applied climatology studies relative to tropical cyclone intensity are currently underway at Headquarters First Weather Wing, USAF in Hawaii and at the Navy Weather Research Facility in Norfolk, Virginia.

H. A CLIMATOLOGICAL STUDY OF SUPER TYPHOONS

1. INTRODUCTION:

One of the most awesome natural forces on earth is the super typhoon. The name Super Typhoon was coined to catagorize the stronger and larger typhoons of the Northwestern Pacific. By definition any typhoon that attains at least 130 knots sustained surface winds during its lifetime is recorded as a super typhoon. It is not known when this classification was first conceived. The first known reference to the term was by Kinney (1955) when he used it to describe large typhoons in general. The Glossary of Meteorology (1959) makes no mention of the term. The first official use of the term by JTWC was in their 1963 Annual Typhoon Report. Nevertheless it has attained common usage both as a technical classification and by the news media as a descriptive term for the stronger typhoons. It is quite probable that the 130 knot delineation was chosen because it is the value, to the nearest 5 kts, that is twice the 64 knot intensity adopted for classification as a typhoon.

2. PROCEDURES:

The dividing line of 130 knots can be difficult to determine since the data are either lacking or those which are observed can be highly subjective, particularly at these extreme intensities. However, since the establishment of the Pacific Command Joint Typhoon Warning Service in 1959 routine aerial reconnaissance coverage of tropical cyclones in the Western Pacific has been rather thorough and subsequent documentation of these storms by the Joint Typhoon Warning Center (JTWC) has been quite comprehensive. It is felt that the data accumulated by JTWC during the past 12 years for 231 typhoons constitute a fairly accurate base and population upon which to build a climatology of super typhoons.

The annual typhoon reports for 1959 through 1970 (FWC/JTWC, 1959-1970) were consulted. All typhoons that were best tracked at 130 knots or more were listed. Seventy-two typhoons were documented as super typhoons. The data on each of these were examined to weed out any obvious overestimations. Since observing surface winds in excess of 100 knots is highly subjective each of the storms was required to pass a minimum sea level pressure correlation test. Holliday (1969) listed most of the accepted equations in use today for correlating maximum surface winds in a tropical cyclone with the recorded minimum sea level pressure. Of the non-latitude influenced equations, Fletcher's (1955) is the most liberal wherein maximum sustained wind, in knots, $V_{max}=16\sqrt{1010-P_c}$, where P_c is the minimum sea level pressure (mb). In order to give the benefit of any doubt to the storm his equation was used to test the 72 typhoons for consistency. No attempt was made to upgrade any typhoons not

SUPER TYPHOONS
(1959-1970)

YEAR	NAME	BECAME SUPER TYPHOON DATE/TIME(Z)	LOCATION LAT (N)	LOCATION LONG (E)	LOWEST SLP DURING LIFETIME
1970	OLGA	30 JUN 2300	17.7	128.8	904
	ANITA	19 AUG 1400	25.4	136.8	912
	GEORGIA	10 SEP 1100	15.6	124.3	904
	HOPE	23 SEP 1800	20.2	148.0	895
	JOAN	12 OCT 1100	12.2	126.7	901
	KATE	18 OCT 0500	06.0	126.4	938
	PATSY	18 NOV 0500	14.4	127.3	918
1969	VIOLA	25 JUL 2300	17.6	126.3	897
	ELSIE	22 SEP 2300	18.1	145.0	890
1968	MARY	23 JUL 2300	20.8	141.1	924
	WENDY	30 AUG 1700	18.9	144.0	917
	AGNES	03 SEP 0500	17.6	141.0	904
	ELAINE	26 SEP 1800	16.0	126.0	908
	FAYE	04 OCT 1700	18.6	162.1	911
1967	OPAL	02 SEP 1800	19.4	161.0	919
	CARLA	14 OCT 0600	13.0	134.8	901
	EMMA	02 NOV 0300	10.5	131.6	908
	GILDA	13 NOV 1800	15.0	141.1	890
1966	KIT	25 JUN 1400	17.1	130.8	912
	ALICE	01 SEP 1200	25.8	128.7	937
	CORA	02 SEP 1800	22.3	131.9	917
1965	DINAH	15 JUN 1800	15.3	129.0	932
	FREDA	12 JUL 0300	14.5	127.8	922
	JEAN	04 AUG 0300	25.7	126.8	940
	LUCY	17 AUG 1200	23.6	154.5	940
	MARY	17 AUG 0100	20.9	129.3	936
	OLIVE	28 AUG 1800	21.4	148.1	936
	SHIRLEY	09 SEP 1800	31.3	132.9	936
	TRIX	14 SEP 0000	22.2	131.1	930
	BESS	29 SEP 1200	18.8	143.6	901
	CARMEN	06 OCT 1200	18.0	146.0	916
	FAYE	23 NOV 0000	14.4	130.1	925
1964	HELEN	30 JUL 0000	23.3	142.6	931
	IDA	06 AUG 0000	16.2	126.3	927
	SALLY	06 SEP 0600	14.8	138.4	894
	WILDA	20 SEP 1800	20.1	139.3	905
	LOUISE	17 NOV 0600	07.1	132.7	914
	OPAL	11 DEC 1200	08.3	135.9	903
1963	SHIRLEY	15 JUN 1200	16.3	130.9	935
	WENDY	12 JUL 1200	15.9	139.8	928
	BESS	04 AUG 1200	20.7	136.8	930
	GLORIA	08 SEP 1800	21.1	128.9	921
	JUDY	02 OCT 0200	23.0	143.1	917
	KIT	09 OCT 0000	20.9	132.1	929
	LOLA	17 OCT 1200	21.1	135.8	945
	SUSAN	25 DEC 0600	14.9	143.5	932
1962	GEORGIA	20 APR 0000	14.4	141.0	936
	OPAL	04 AUG 2000	21.0	124.8	910
	RUTH	15 AUG 1800	20.2	145.8	916
	AMY	01 SEP 0900	19.0	132.9	935
	EMMA	04 OCT 1200	20.7	145.8	903
	KAREN	08 NOV 1630	09.8	152.6	897
1961	TESS	28 MAR 0600	14.1	135.5	937
	BETTY	25 MAY 1200	19.1	122.9	946
	NANCY	08 SEP 1800	09.0	156.8	882
	PAMELA	10 SEP 2300	23.6	127.5	914
	TILDA	29 SEP 1200	20.4	138.0	917
	VIOLET	06 OCT 0000	16.5	143.5	882
	DOT	09 NOV 1800	17.8	149.1	922
	ELLEN	08 DEC 1200	13.5	125.9	945
1960	SHIRLEY	30 JUL 1500	22.4	124.0	908*
	OPHELIA	30 NOV 1200	11.1	137.3	928
1959	TILDA	19 APR 0600	14.5	137.2	930*
	JOAN	28 AUG 0130	18.8	130.0	891
	SARAH	14 SEP 0200	19.9	129.3	905
	VERA	22 SEP 2200	18.0	144.2	896
	CHARLOTTE	12 OCT 1800	17.0	126.6	905
	DINAH	18 OCT 1200	11.7	143.9	913
	GILDA	16 DEC 0600	09.9	131.5	914
	HARRIET	30 DEC 0000	14.2	127.4	926

*Extrapolated from min 700 mb height

TABLE 3-11

SUPER TYPHOONS

YEAR	J	F	M	A	M	J	J	A	S	O	N	D	SUPER TYPHOONS	TYPHOONS	RATIO
						MONTH									
1959				1				1	2	2		2	8	17	.47
1960							1				1		2	19	.11
1961			1		1				3	1	1	1	8	20	.40
1962				1				2	1	1	1		6	24	.25
1963						1	1	1	1	3		1	8	19	.42
1964							1	1	2		1	1	6	26	.23
1965						1	1	4	3	1	1		11	21	.52
1966						1			2				3	20	.15
1967									1	1	2		4	20	.20
1968							1	1	2	1			5	20	.25
1969							1		1				2	13	.15
1970						1		1	2	2	1		7	12	.58
TOTAL	0	0	1	2	1	4	6	11	20	12	8	5	70	231	.30
TYPHOONS	2	1	2	9	12	13	33	53	38	39	21	8	231		
RATIO SUPER TYPHOONS TO TYPHOONS						.31	.18	.21	.53	.33	.42	.63	.30		
RATIO SUPER TYPHOONS TO TYPHOONS						.21			.42						

ANNUAL AVERAGE SUPER TYPHOONS 5.8

ANNUAL AVERAGE TYPHOONS 19.2

TABLE 3-12

best tracked as a super typhoon. Only two typhoons failed the test--Cora '64 (MSLP 967 mb) and Hope '64 (MSLP 973 mb). The complete list of the remaining 70 super typhoons is contained in Table 3-11.

3. SEASONAL DISTRIBUTION:

The month and year when each super typhoon listed attained 130 knots is tabulated in Table 3-12 along with totals by year and month. The total number of typhoons is also listed for comparison. Yearly occurrence of super typhoons range from two (1960 & 1969) to 11 (1965) with an average occurrence of 5.8 per year. The vast majority (94%) of all super typhoons occurred during the period June through December. Note the total monthly frequencies describe a rather normal distribution centered on September which recorded the maximum of 20. In comparison the typhoon data are less normally distributed with a skew toward the early part of the season around a peak of 53 in August. The maximum occurrence of super typhoons during any month was four (Aug '65). Except for 1960, September claimed at least one super typhoon formation each year.

The ratio of super typhoon occurrence to total typhoon occurrence was calculated for the super typhoon season and is shown on the bottom two lines of Table 3-12. The implied probability that a typhoon will reach super typhoon strength shows an explosive increase in September. In fact, this probability is twice as high during the period September through December than it is for the beginning of the typhoon season (June through August). On an annual basis the data indicate that 3 of every 10 typhoons reached the super typhoon threshold. The ratio of super typhoon occurrence to total typhoon occurrence was calculated for each year and is shown in the last column of Table 3-12. Super typhoon to typhoon occurrences range from about 1 in 10 (1960) to near 6 in 10 (1970). No apparent correlation stands out from these data. A graphic plot of the ratios (Figure 3-14) does show a rather interesting pattern, though. Except between 1967 and 1968 the curve shows a rather uniform sawtooth pattern with alternating relatively high and low ratio years.

RATIO OF SUPER TYPHOON OCCURRENCE TO TOTAL TYPHOON OCCURRENCE

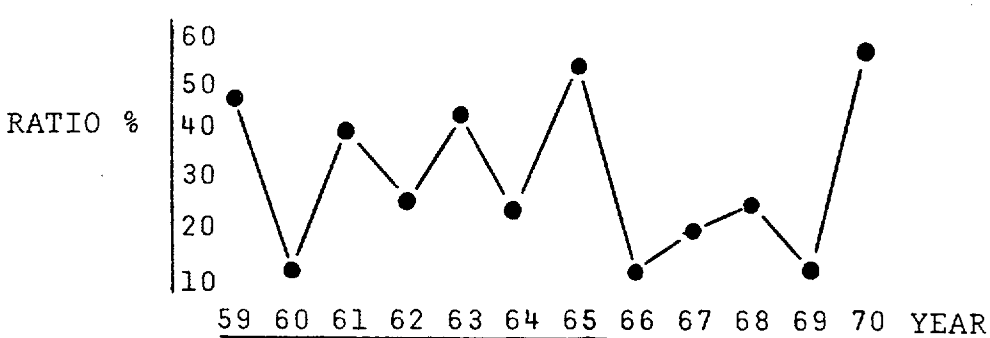


FIGURE 3-14

4. AREAL DISTRIBUTION:

The location where each super typhoon attained 130 knots sustained wind was plotted on a map (Figure 3-15). The Philippine Sea stands out as the primary genesis area. Sixty-two of the 70 super typhoons (89%) attained this distinction in that region. A large majority of all the occurrences (52 or 74%) are concentrated in the 10 degree latitude band from 14°N to 24°N. Note that none formed west of the Philippine Sea. The eastern-most formation was Fay '68 (18.6N 162.1E), the northern-most Shirley '65 (31.3N 132.9E), and the southern-most Kate '70 (6.0N 126.4E). Surprisingly only two developed southeast of Guam (Nancy '61 and Karen '62).

Another view of the areal distribution of the super typhoon genesis points is contained in Figure 3-16. The points were totalled by five degree Marsden squares and isoplethed. The areas of maximum occurrence stand out dramatically in this depiction. One is located in the western part of the Philippine Sea with another located along the eastern entrance to the Sea. A definite minima is situated between the two. This double maxima closely fits the doublet structure charted by FUNG Yat-kong (1970) of mean minimum pressure of typhoons for the period 1958-1968. His western-most minima is displaced 5 degrees north of our max occurrence area while his eastern-most minima is displaced about 400 miles northwest of our eastern maxima. This logically places the minimum pressure areas climatologically downstream from the areas of maximum super typhoon formation.

Figure 3-16 indicates the western maxima is higher than the eastern one. In reality, the eastern maxima represents a higher probability of a typhoon traversing the area becoming a super typhoon than does the western maxima. During this period (1959-1970) 51 typhoons moved through the square enclosing the western maximum super typhoon occurrence while only 33 traversed the eastern square. This indicates that 1 out of every 6 or 7 typhoons that passed through the western area intensified to super strength whereas in the eastern area about 1 out of 5 did.

5. SUMMARY:

Data for the period 1959 through 1970 indicate that super typhoons (maximum surface winds $\geq$ 130 knots) are relatively common occurrences in the Northwestern Pacific. Three of every 10 typhoons can be expected to intensify to super typhoon strength. The annual average is six with yearly extremes ranging from 2 to 11. Ninety-four percent form during the period June through December. The probability of a typhoon becoming a super typhoon during the period September through December is double the expectancy of the period June through August. September recorded the most super typhoon occurrences. During this month half of the typhoons reached super strength.

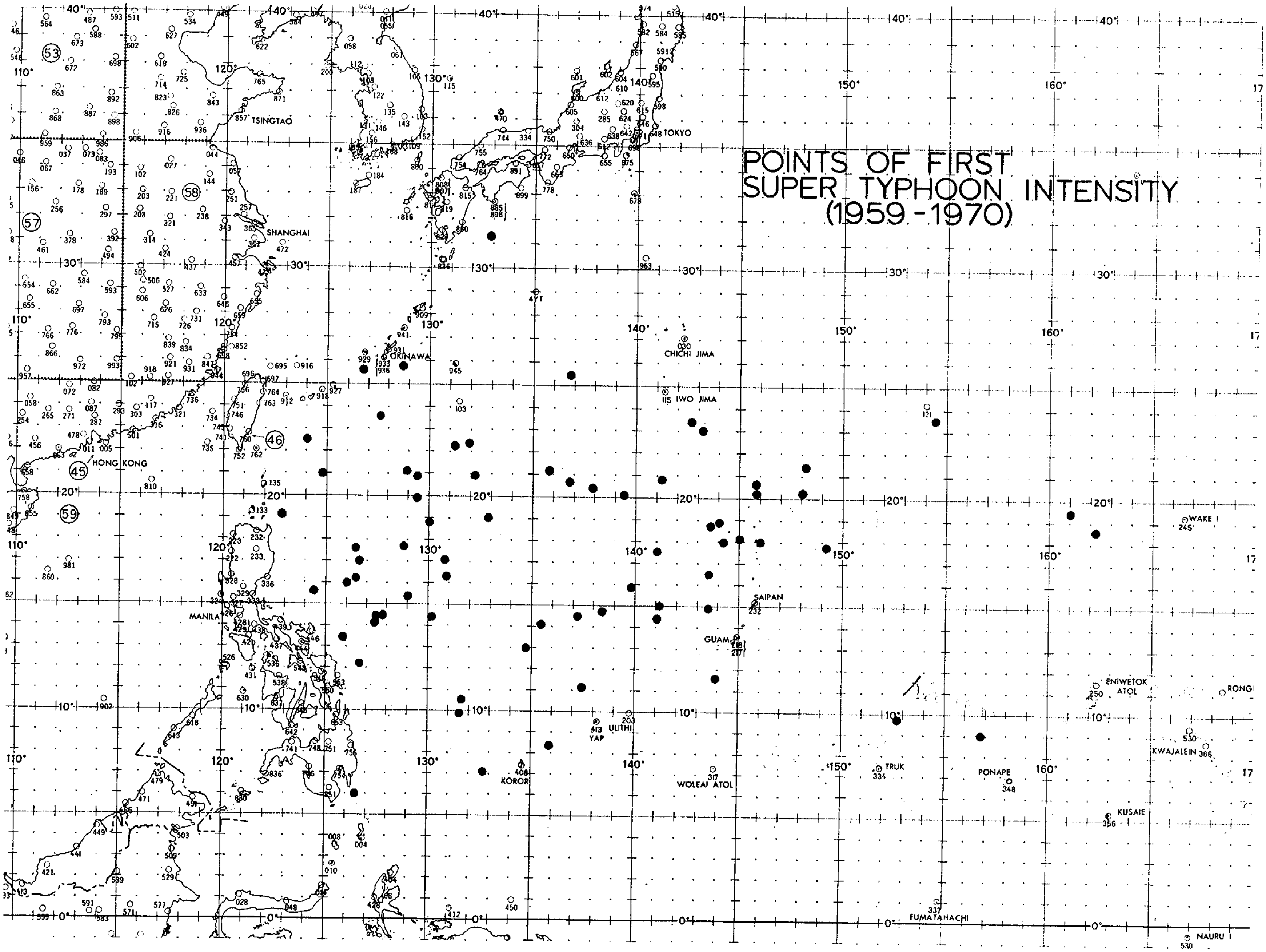

POINTS OF FIRST
SUPER TYPHOON INTENSITY
(1959-1970)
TSINGTAO
SHANGHAI
TOKYO
OKINAWA
CHICHI JIMA
IWO JIMA
HONG KONG
MANILA
SAIPAN
GUAM
YAP
ULITHI
KOROR
WOLEAI ATOL
TRUK
PONAPE
ENIWETOK ATOL
KWAJALEIN
KUSAIE
WAKE I
NAURU I

FIGURE 3-15

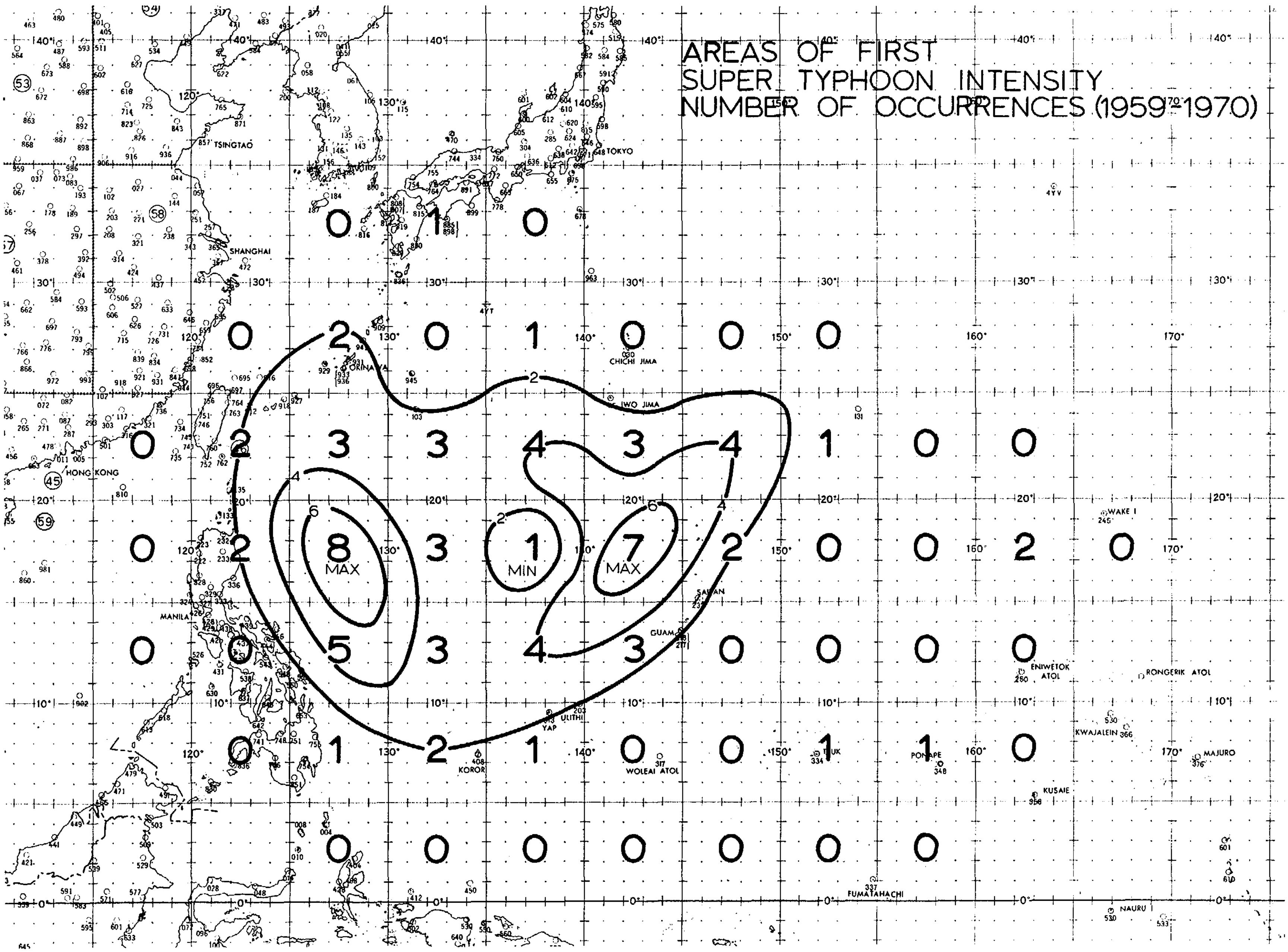

AREAS OF FIRST
SUPER TYPHOON INTENSITY
NUMBER OF OCCURRENCES (1959-1970)
MAX
MIN
MAX
TOKYO
TSINGTAO
SHANGHAI
HONG KONG
MANILA
OKINAWA
CHICHI JIMA
IWO JIMA
SAIPAN
GUAM
ULITHI
YAP
KOROR
WOLEAI ATOL
TRUK
PONAPE
KUSAIE
KWAJALEIN
ENIWETOK ATOL
RONGERIK ATOL
MAJURO
WAKE I
NAURU

FIGURE 3-16

I. FREQUENCY OF TROPICAL CYCLONES IN THE WESTERN PACIFIC

Not until the initial impact of aircraft reconnaissance in 1945 did a satisfactory set of statistics become available on the tropical cyclone occurrences in the West Pacific area. The Royal Observatory at Hong Kong has prepared an exhaustive study of tropical cyclone climatology from 1884-1953 data (Chin, 1958), however, it is limited to an area west of the 150th meridian. Statistics varied as different military organizations were involved in forecasting these storms. A comparison of data prepared by these sources show a fluctuation of figures prior to 1954.

In an effort to standardize the data for reference purposes at JTWC, a search has been made of available sources for the most reliable and representative set of frequency statistics. Research by the Environmental Data Service (NOAA) of figures available at the National Weather Records Center in Asheville is regarded as the most comprehensive study on the subject. This study was conducted in the preparation of the TYFOON analog program history file under NAVWEARSCHFAC sponsorship with JTWC cooperation. JTWC believes this to be the most representative set of statistics available and regards it as the official data base. These data are summarized in Tables 3-13 and 3-14.

FREQUENCY OF TROPICAL CYCLONES (INCLUDING TYPHOONS) BY MONTHS AND YEARS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1945	0	0	0	1	1	2	5	7	6	1	3	0	26
1946	0	0	1	0	1	2	3	2	3	1	2	0	15
1947	0	0	1	0	1	1	3	3	5	6	6	1	27
1948	1	0	0	0	2	2	2	5	5	4	3	2	26
1949	1	0	0	0	0	1	5	3	6	1	3	2	22
1950	0	0	0	0	1	2	3	2	3	3	3	1	18
1951	0	0	1	2	1	1	1	2	2	4	1	2	17
1952	0	0	0	0	0	3	3	4	5	6	3	4	28
1953	0	1	0	0	1	2	2	6	3	4	3	1	23
1954	0	0	1	0	1	0	1	6	4	3	3	0	19
1955	1	0	1	1	0	1	6	3	3	4	1	1	22
1956	0	0	1	2	0	1	2	5	5	2	3	1	22
1957	2	0	0	1	1	1	1	3	5	4	3	0	21
1958	1	0	0	0	1	3	5	3	3	3	2	1	22
1959	0	1	1	1	0	0	3	6	6	4	2	2	26
1960	0	0	0	1	1	3	3	10	3	4	1	1	27
1961	1	1	1	1	3	2	5	4	6	5	1	1	31
1962	0	1	0	1	2	0	6	7	3	5	3	2	30
1963	0	0	0	1	1	3	4	3	5	5	0	3	25
1964	0	0	0	0	2	2	7	9	7	6	6	1	40
1965	2	2	1	1	2	3	5	6	7	2	2	1	34
1966	0	0	0	1	2	1	5	8	7	3	2	1	30
1967	1	0	2	1	1	1	6	8	7	4	3	1	35
1968	0	0	0	1	1	1	3	8	3	6	4	0	27
1969	1	0	1	1	0	0	3	4	3	3	2	1	19
1970	0	1	0	0	0	2	2	6	4	5	4	0	24
1971	1	0	1	3	4	[illegible]	8	[illegible]	6	4	[illegible]	[illegible]	35
Totals	11	7	12	17	26	40	94	133	119	98	69	30	656
Avg.	.42	.27	.46	.65	1.00	1.54	3.62	5.12	4.58	3.76	2.65	1.15	25.23

TABLE 3-13

FREQUENCY OF TROPICAL CYCLONES REACHING TYPHOON INTENSITY BY MONTHS AND YEARS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1945	0	0	0	0	0	1	2	5	3	1	1	0	13
1946	0	0	1	0	1	1	3	1	3	1	2	0	13
1947	0	0	0	0	1	1	0	3	4	5	4	1	19
1948	1	0	0	0	2	0	2	2	4	1	2	1	15
1949	1	0	0	0	0	1	3	3	3	1	1	1	14
1950	0	0	0	0	1	1	1	2	1	3	2	1	12
1951	0	0	1	2	1	1	1	2	2	3	1	2	16
1952	0	0	0	0	0	3	1	3	3	4	3	2	19
1953	0	1	0	0	1	1	2	4	2	4	1	1	17
1954	0	0	0	0	1	0	1	4	4	2	3	0	15
1955	1	0	1	1	0	1	5	3	3	2	1	1	19
1956	0	0	1	1	0	0	2	4	5	1	3	1	18
1957	1	0	0	1	1	1	1	2	5	3	3	0	18
1958	1	0	0	0	1	3	4	3	3	3	1	1	20
1959	0	0	0	1	0	0	1	5	3	3	2	2	17
1960	0	0	0	1	0	2	2	8	0	4	1	1	19
1961	0	0	1	0	2	1	3	3	5	3	1	1	20
1962	0	0	0	1	2	0	5	7	2	4	3	0	24
1963	0	0	0	1	1	2	3	3	3	4	0	2	19
1964	0	0	0	0	2	2	6	3	5	3	4	1	26
1965	1	0	0	1	2	2	4	3	5	2	1	0	21
1966	0	0	0	1	2	1	3	6	4	2	0	1	20
1967	0	0	1	1	0	1	3	4	4	3	3	0	20
1968	0	0	0	1	1	1	1	4	3	5	4	0	20
1969	1	0	0	1	0	0	2	3	2	3	1	0	13
1970	0	1	0	0	0	1	0	4	2	3	1	0	12
	0	0	0	3	1	2	6	3	5	2	2	0	24
Totals	7	2	6	14 17	22 23	28 30	61 67	94 97	83 88	73 75	49 51	20	459 483
Avg.	.27	.08	.23	.54	.85	1.08	2.35	3.62	3.19	2.81	1.88	.77	17.65
	.26	.07	.22	.63	.85	1.11	2.48	3.59	3.26	2.78	1.89	.74	17.89

TABLE 3-14

REFERENCES:

Arakawa, H., "Studies on Statistical Prediction of Typhoons," National Hurricane Research Project Report No. 61, U. S. Weather Bureau, Washington, D.C., April 1963, 15pp.

Brand, Samson, "Interaction of Binary Tropical Cyclones of the Western Pacific Ocean," NAVWEARSCHFAC Tech Paper No. 26-68, Norfolk, Va., September 1968.

Chin, P. C., Tropical Cyclones in the Western Pacific and China Sea Area from 1884 to 1953, Royal Observatory, Hong Kong, 1958.

Dvorak, V., "Tropical and Subtropical Disturbance Classification from Satellite Data," National Environmental Satellite Center Analysis Branch, June 1968.

Fletcher, R., "Computation of Maximum Surface Winds in Hurricanes," Bulletin of the American Meteorological Society, Vol. 36, June 1955, pp. 247-250.

Frank, N. L., "Atlantic Tropical Systems of 1969," Monthly Weather Review, Vol. 98, No. 4, April 1970, pp. 307-314.

Fujiwhara, S., Quarterly Journal of the Royal Meteorological Society, Vol. 47, 1921.

Fujiwhara, S., ibid., Vol. 49, 1923.

FUNG Yat-kong, "A Statistical Analysis of the Intensity of Typhoons: 1958-1968," Tech. Note No. 9, Royal Observatory, Hong Kong, March 1970.

FWC/JTWC (Fleet Weather Central/Joint Typhoon Warning Center), Annual Typhoon Report - Series 1959-1970, Guam, Marianas Islands.

Glossary of Meteorology, Huschke, R. E. (ed.), American Meteorological Society, Boston, Mass., 1959.

Hardie, J. S., "Tropical Storm Steering Using Geostrophic Winds Derived from Smoothed 700 MB and 500 MB Height Fields," Naval Postgraduate School Master's Thesis, June 1967.

Holliday, C. R., "A Comparison of Hurricane Center Fixes Made by Land Based Radar and Reconnaissance Aircraft," ESSA Tech. Note 31--Radar--1, Washington, D. C., January 1966.

Holliday, C. R., "On the Maximum Sustained Winds Occurring in Atlantic Hurricanes," ESSA Tech. Memorandum WBTM-SR-45, May 1969.

REFERENCES (Cont'd):

Hope, J. R., and C. J. Neumann, "An Operational Technique for Relating the Movement of Existing Tropical Cyclones to Past Tracks," Monthly Weather Review, Vol. 98, No. 12, pp 925-933.

Hubert, L., and A. Timchalk, "Estimating Hurricane Wind Speeds from Satellite Pictures," Monthly Weather Review, Vol. 97, No. 5, May 1969.

Hubert, W., "The Pacific Tropical Analysis and Prediction Program" in "Proceedings of the Working Panel on Tropical Dynamic Meteorology," NWRF Report 12-1167-132, Norfolk, Va., August 1967.

Jarrell, J. D., and W. L. Somervell, Jr., "A Computer Technique for Using Typhoon Analogs as a Forecast Aid," NAVWEARSCHFAC Tech. Paper No. 6-70, June 1970.

Jordan, C., "Tracking of Tropical Cyclones," NWRF Report 12-0763-075, Norfolk, Va., July 1963.

Jordan, C., and L. Fortner, "Estimation of Surface Wind Speeds in Tropical Cyclones," Bulletin of the American Meteorological Society, Vol. 41, No. 1, January 1960.

Jordan, C., and L. Fortner, "Reply," ibid., Vol. 42, No. 5, May 1961.

Kinney, J. J. R., Typhoon Forecasting Guide, Tokyo Weather Central, 1955.

LaSeur, N., "On the Structure of Tropical Disturbances and Hurricanes," NATO Symposium, London, July 1966.

Miller, B. I., "On the Maximum Intensity of Hurricanes," National Hurricane Research Project Report No. 14, U. S. Weather Bureau, Washington, D. C., December 1957, 19pp.

Navy Weather Research Facility, "A Preliminary Survey of SEASIA Fall Transformation Season Weather," NAVWEARSCHFAC Tech. Paper No. 10-7, September 1970.

Renard, R. J., M. J. Daley, and S. K. Rinard, "A Recent Improvement in the Navy's Numerical-Statistical Scheme for Forecasting Motion of Hurricanes and Typhoons," Naval Postgraduate School Publ. 51RD0011A, January 1970.

Riehl, H., Tropical Meteorology, McGraw-Hill Book Company, Inc., New York, 1954, 392pp.

REFERENCES (Cont'd):

Simpson, J., M. Garstang, E. Zipser, and G. Dean, "A Study of a Nondeepening Tropical Disturbance," Journal of Applied Meteorology, Vol. 6, No. 2, April 1967.

Simpson, R., "The Decision Process in Hurricane Forecasting," NOAA Tech. Memorandum NWS SR-53, Fort Worth, Texas, January 1971.

Takahashi, K., "Distribution of Pressure and Wind in a Typhoon," Journal of the Meteorological Society of Japan, 2nd Series, Vol. 17, No. 11, November 1939, pp. 417-421.

Williams, Knox, "A Statistical Analysis of Satellite-Observed Trade Wind Cloud Clusters in the Western North Pacific," Atmospheric Science Paper No. 161, Colorado State University, June 1970.

Zipser, E., "The Line Islands Experiment, Its Place in Tropical Meteorology and the Rise of the Fourth School of Thought," Bulletin of the American Meteorological Society, Vol. 15, No. 12, December 1970.

CHAPTER 4

SUMMARY OF TROPICAL CYCLONES 1970

SUMMARY OF WESTERN PACIFIC
TROPICAL CYCLONES
OF 1970

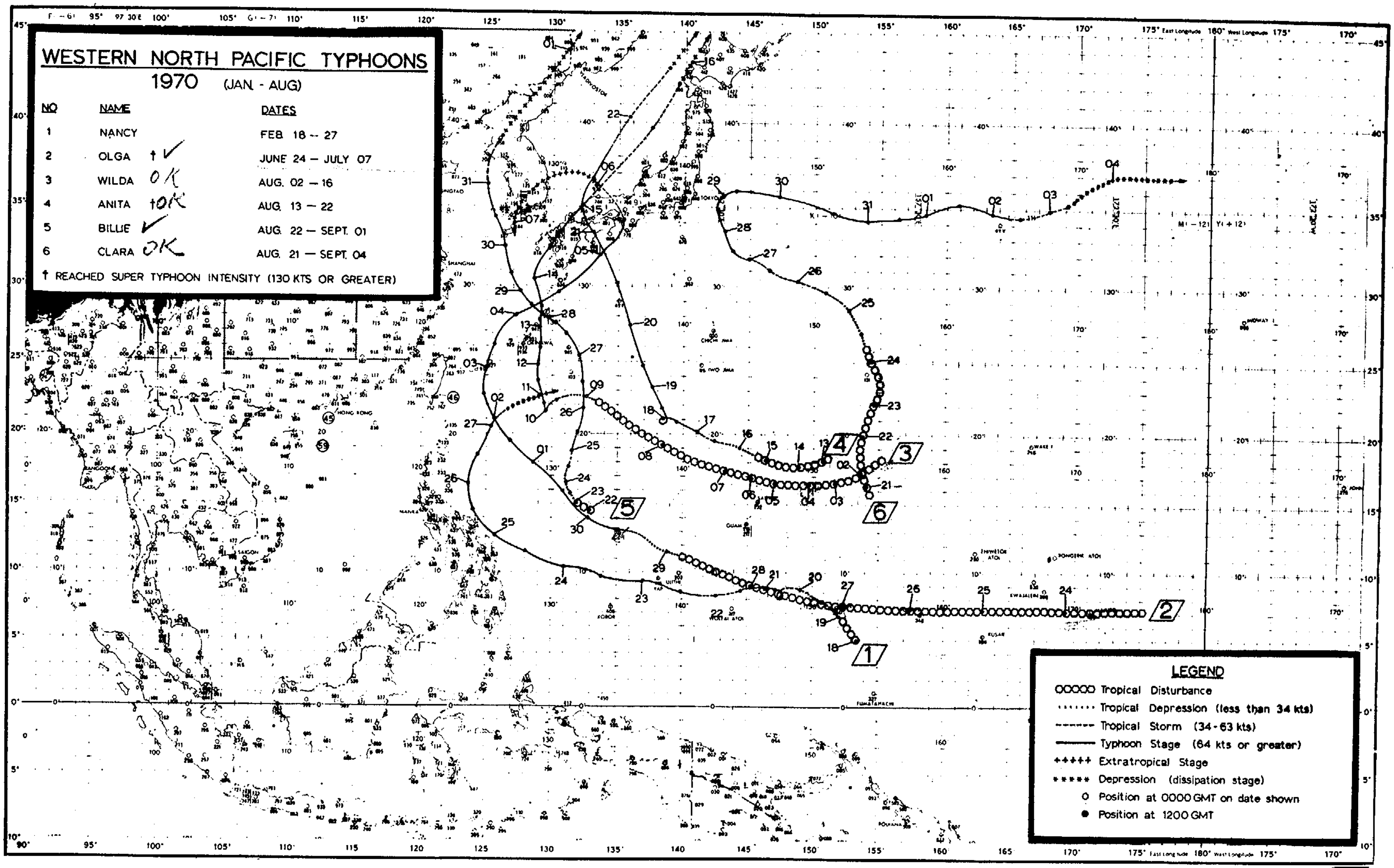
	1960-1969 (AVE)	1969	1970
TOTAL NUMBER OF WARNINGS	750	430	533
CALENDAR DAYS OF WARNING	153	108	127
NUMBER OF WARNING DAYS WITH TWO OR MORE CYCLONES	56	15	29
NUMBER OF WARNING DAYS WITH THREE OR MORE CYCLONES	14	1	0
TROPICAL DEPRESSIONS	6	4	3
TROPICAL STORMS	10	6	12
TYPHOONS	20	13	12
TOTAL TROPICAL CYCLONES	36	23	27

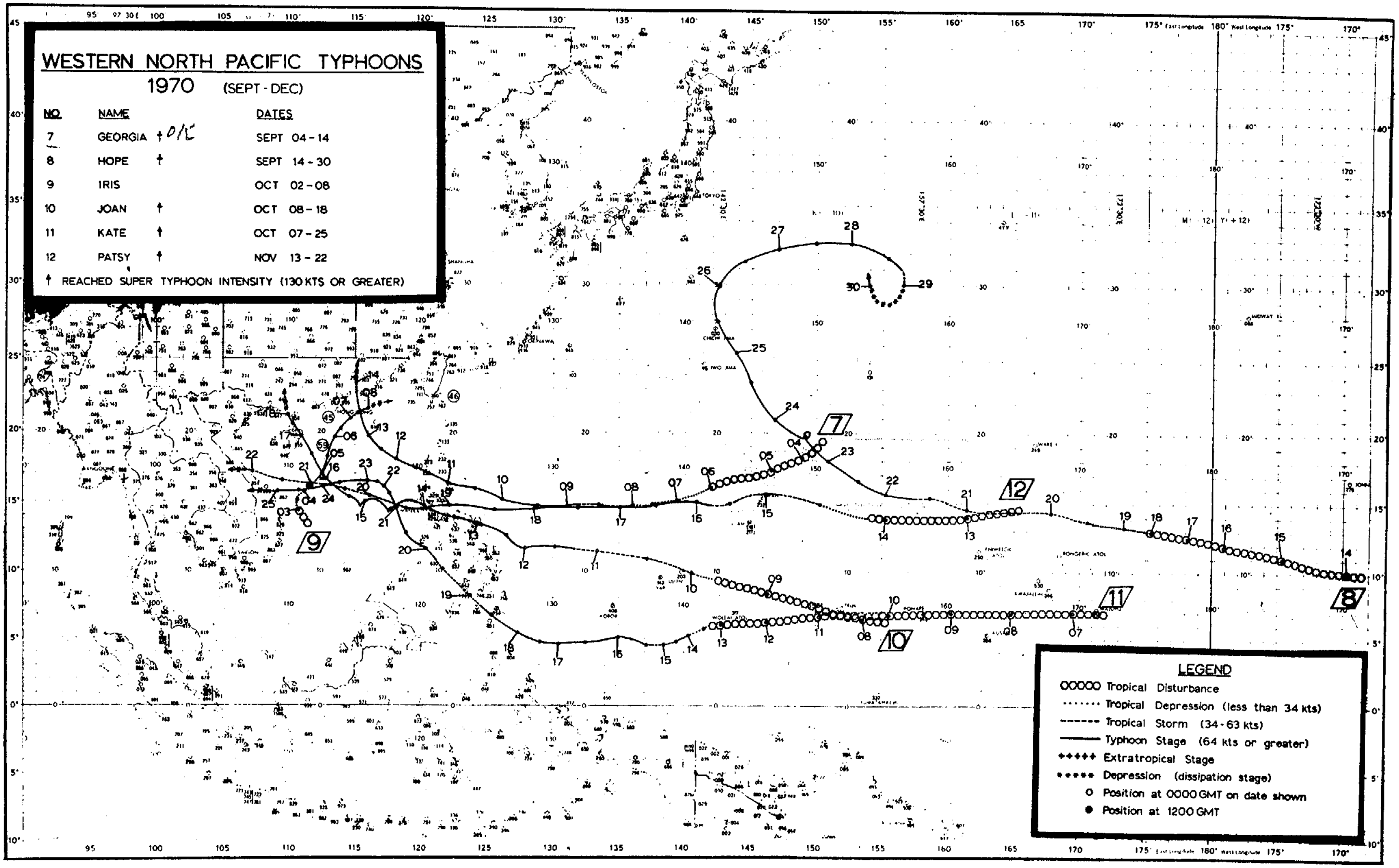
TABLE 4-1

SUPER TYPHOONS DURING 1970

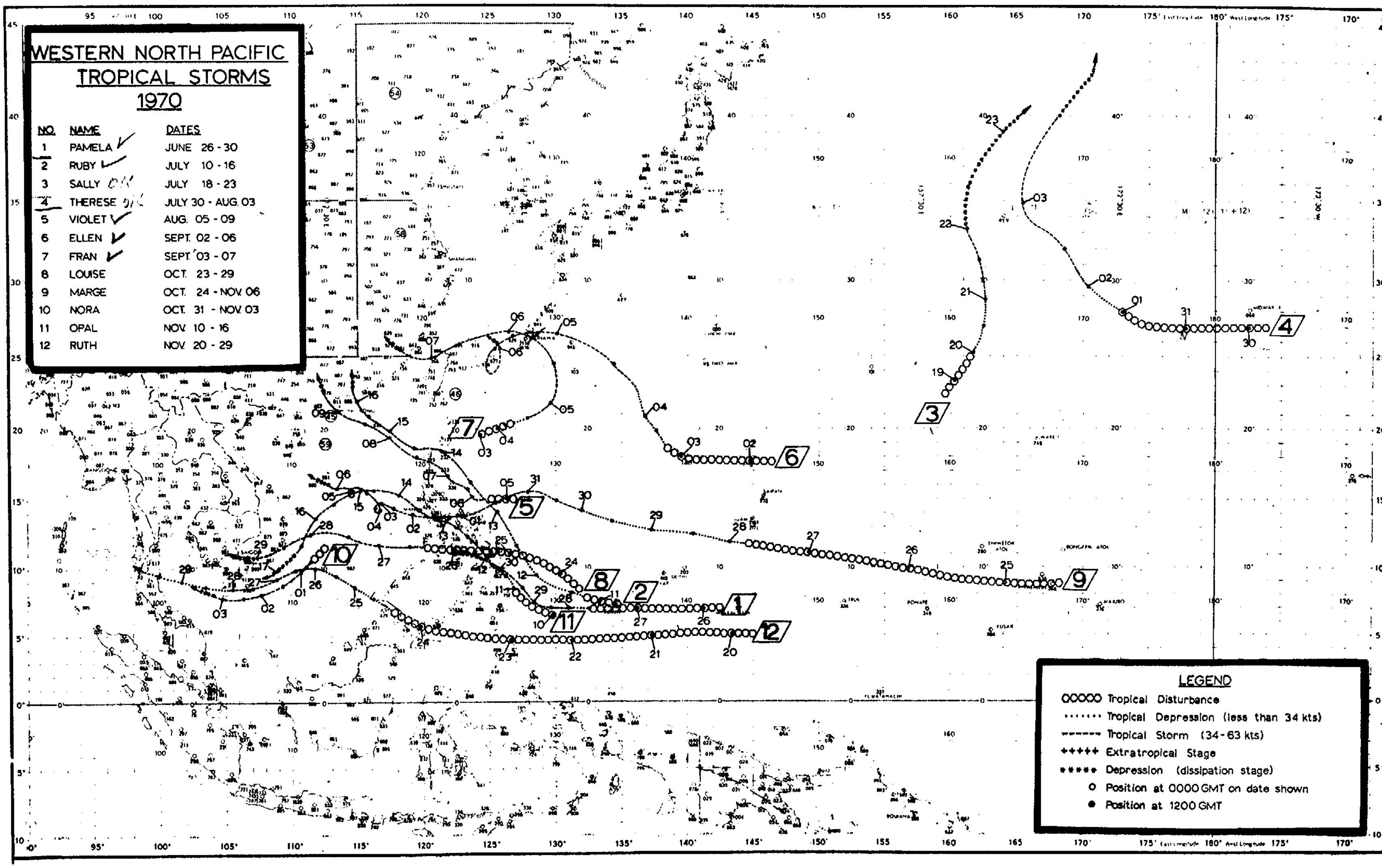
CYCLONE NUMBER	NAME	INCLUSIVE DATES	MAX INTENSITY	MIN SLP	MIN 700 MB HT
02	OLGA	28 JUN-05 JUL	130 140 KNOTS	904 MB	2268 m
11	ANITA	16 AUG-22 AUG	125 135 KNOTS	912 MB	2325 m
17	GEORGIA	07 SEP-14 SEP	130 140 KNOTS	904 MB	2390 m
18	HOPE	19 SEP-29 SEP	140 150 KNOTS	895 MB	2219 m
21	JOAN	09 OCT-18 OCT	135 150 KNOTS	901 MB	2332 m
22	KATE	14 OCT-25 OCT	100 130 KNOTS	938 MB	2554 m
27	PATSY	14 NOV-22 NOV	120 135 KNOTS	918 MB	2256 m

TABLE 4-2


WESTERN NORTH PACIFIC TYPHOONS
1970 (JAN. - AUG.)
NO NAME DATES
1 NANCY FEB 18 -- 27
2 OLGA † ✓ JUNE 24 — JULY 07
3 WILDA OK AUG. 02 — 16
4 ANITA †OK AUG. 13 — 22
5 BILLIE ✓ AUG. 22 — SEPT. 01
6 CLARA OK AUG. 21 — SEPT. 04
† REACHED SUPER TYPHOON INTENSITY (130 KTS OR GREATER)
LEGEND
Tropical Disturbance
Tropical Depression (less than 34 kts)
Tropical Storm (34-63 kts)
Typhoon Stage (64 kts or greater)
Extratropical Stage
Depression (dissipation stage)
Position at 0000GMT on date shown
Position at 1200GMT
HONG KONG
SHANGHAI
SAIGON
MANILA
GUAM
TOKYO



WESTERN NORTH PACIFIC TYPHOONS
1970 (SEPT - DEC)
NO. NAME DATES
7 GEORGIA † O/K SEPT 04 - 14
8 HOPE † SEPT 14 - 30
9 IRIS OCT 02 - 08
10 JOAN † OCT 08 - 18
11 KATE † OCT 07 - 25
12 PATSY † NOV 13 - 22
† REACHED SUPER TYPHOON INTENSITY (130 KTS OR GREATER)
LEGEND
OOOOO Tropical Disturbance
.... Tropical Depression (less than 34 kts)
------ Tropical Storm (34 - 63 kts)
—— Typhoon Stage (64 kts or greater)
+++++ Extratropical Stage
••••• Depression (dissipation stage)
○ Position at 0000 GMT on date shown
● Position at 1200 GMT



WESTERN NORTH PACIFIC
TROPICAL STORMS
1970
NO. NAME DATES
1 PAMELA JUNE 26 - 30
2 RUBY JULY 10 - 16
3 SALLY JULY 18 - 23
4 THERESE JULY 30 - AUG. 03
5 VIOLET AUG. 05 - 09
6 ELLEN SEPT. 02 - 06
7 FRAN SEPT. 03 - 07
8 LOUISE OCT. 23 - 29
9 MARGE OCT. 24 - NOV. 06
10 NORA OCT. 31 - NOV. 03
11 OPAL NOV. 10 - 16
12 RUTH NOV. 20 - 29
LEGEND
OOOOO Tropical Disturbance
······· Tropical Depression (less than 34 kts)
------ Tropical Storm (34-63 kts)
+++++ Extratropical Stage
***** Depression (dissipation stage)
○ Position at 0000 GMT on date shown
● Position at 1200 GMT

GENERAL SUMMARY, WESTERN PACIFIC TYPHOON SEASON OF 1970

Twenty four tropical storms were observed in the West Pacific during the 1970 season, twelve of which developed to typhoon strength. Hurricane Dot[1] came close to being added to the list but veered off to the northeast after approaching within 30 miles of the International Date Line northwest of Midway Island.

Although the number of tropical storms (24) was only one less than the average for the past 25 year period, this is the second consecutive season that typhoon frequency has been below normal. 1970 was the lightest year for typhoon activity in two decades (tying a previous low in 1950) and compares with an average of 18 since 1945[2] (see Table 4-3). The number of typhoon days, however, actually saw an increase of 17 days over 1969 as storms were longer lived (see Table 4-4).

AVERAGE MONTHLY FREQUENCY OF TYPHOONS
IN THE WESTERN NORTH PACIFIC DURING PERIOD
1945-1969 COMPARED WITH 1970 SEASON

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1945-69	.3	*	.2	.6	.9	1.1	2.4	3.6	3.2	2.8	1.9	.8	17.9
1970	0	1	0	0	0	1	0	4	2	3	1	0	12

*Less than .05

TABLE 4-3

An uncommon feature this year was the off-season Typhoon Nancy. The unlikelihood of such an event is evidenced in the fact that only one other storm reaching typhoon force has been recorded during the month of February since 1945.

One can only conjecture as to the reasons for the low total of typhoons in 1970. Except for August the subtropical ridge was not consistently developed in either strength or longitudinal extent during the major typhoon months. This inhibited a regime for a persistent fetch of developed easterlies across the climatological development zone of the West Pacific.

[1]Name Dot was transferred from West Pacific list to hurricane which developed in the Central Pacific.

[2]Records compiled by U. S. agencies began in 1945; JTWC established in 1959.

TYPHOON DAYS 1959-1970

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL PER YEAR
1959	---	---	---	8	---	---	3	18	19	18*	10*	18	94
1960	---	---	---	2	---	10	13	36*	---	23*	2	12	98
1961	---	---	8	---	8	2	10*	15	23*	17*	6	6	95
1962	---	---	---	7	4	---	14*	37*	8	30*	19*	---	119
1963	---	---	---	4	5	15	11	23*	14*	24*	---	11	107
1964	---	---	---	---	7	5*	22*	18*	28*	14	11*	6	111
1965	2	---	---	2	5	12*	19*	23*	25*	14	6	---	108
1966	---	---	---	5	11	6	7*	16*	23*	11	4	3	84
1967	---	---	2	7	---	4	14*	10	32*	21*	21*	---	111
1968	---	---	---	6	1	7	6	8	32*	19	18*	---	96
1969	5	---	---	5	---	---	8	6	10	18	10*	---	62
1970	---	5	---	---	---	2	5	24*	16	21*	6	---	79
TOTAL	7	5	10	46	41	63	132	234	230	229	112	56	1165

*Two typhoons occurring on the same day are counted as two typhoon days.

TABLE 4-4

LIST OF METEOROLOGICAL DATA, ESTIMATED CASUALTIES, AND AFFECTED GEOGRAPHICAL LOCATIONS FOR THE TYPHOON SEASON 1970

TYPHOON	MINIMUM PRESSURE (MB)	MAXIMUM WIND (KT)	DEATHS	MISSING	PRINCIPAL AREAS AFFECTED
NANCY	949	120	---	---	Yap and the Philippines
OLGA	904	140	37	---	Ryukyu's, Japan, and Korea
WILDA	939	105	11	1	Ryukyu's and Japan
ANITA	912	135	23	4	Japan
BILLIE	945	110	15	---	Ryukyu's and Korea
CLARA	965	85	---	---	Remained over water
GEORGIA	904	140	95	80	Philippines, Hong Kong, and South China
HOPE	895	150	---	---	Chi Chi Jima Island
IRIS	944	100	---	---	Parcel Islands
JOAN	901	150	575	193	Philippines, Parcel Islands, Hong Kong, and South China
KATE	938	130	631	284	Philippines and Vietnam
PATSY	918	135	241	351	Philippines and Vietnam
		TOTAL	1,628	913	

TABLE 4-5

As a result of this abnormal synoptic pattern, tradewind-produced cyclonic wind shear was weak as was the mechanism for mass transport towards developing depression centers. Both of these environmental conditions have been emphasized by Simpson (1971) as important for development.

The most striking period of inactivity was the lack of development during the month of July. Usually averaging 2 typhoons, the period was void of generation for the first time in 23 years dating back to 1947. Mean 700 mb height anomaly pattern for July indicated a blocking ridge situation over eastern Siberia with below normal geopotential heights in the subtropics west of Wake Island (Green, 1970). It is a similar pattern to that shown unfavorable for development in the Atlantic (Sugg and Hebert, 1969). A weak persistent trough extended from the mid-latitudes east of Japan into the tropics near the Marianas chain during most of the month slowly retrograding during the latter portion. Thus easterly flow across the tropical West Pacific was generally disrupted and underdeveloped--a condition not favored for typhoon generation.

The upper-tropospheric Mid-Pacific trough, noted by Sadler (1967) as a secondary source of typhoons, acted as an initiator in half of the dozen cases recorded during 1970. This semi-permanent climatological feature was the prime impetus for typhoons during August and early September. The axis of the shearline reached westward from Midway to the vicinity of Marcus Island during this period. Four cyclonic cells on its westward extension penetrated downward inducing surface troughs in the easterlies which later developed into typhoons Wilda, Anita, Clara, and Georgia.

The percentage of typhoons that became unusually severe was high as seven of the year's twelve crossed the super typhoon threshold (130 knots or greater). The Republic of the Philippines was especially hard hit as four of these extreme storms delivered their brunt to the archipelago within a three month period (see Table 4-5). Georgia led the succession in September followed by Joan and Kate in October and culminated in Patsy's direct strike on the metropolitan area of Manila in November. The total loss of life in the Philippines as a result of these storms is estimated near 1,550 with an additional 900 persons misssing.

As damage and casualty statistics are incomplete for the West Pacific for the 1970 season, mention is made on an individual basis for each storm narrative. Figures were based on data from the Office of the High Commissioner - Trust Territory of the Pacific Islands, Royal Observatory of Hong Kong, Weather Bureau of the Republic of the Philippines, Japan Meteorological Agency, and the Environmental Data Service - National Oceanic and Atmospheric Administration.

1970 TROPICAL CYCLONES

CYCLONE	TYPE	NAME	DATE*	CALENDAR DAYS OF WARNING	MAX SFC WIND*	MIN OBS SLP	MAX RADIUS SFC CIRC	WARNINGS ISSUED TOTAL	WARNINGS ISSUED NO. AS TYPHOONS	WARNINGS ISSUED DISTANCE TRAVELED*
01	T	NANCY	19 FEB-27 FEB	9	120	949	400	31	19	2,148
02	T	OLGA	28 JUN-05 JUL	8	140	904	360	29	22	2,382
03	TS	PAMELA	29 JUN-30 JUN	4	55	980	120	6	0	385
04	TS	RUBY	11 JUL-16 JUL	6	50	984	240	18	0	922
05	TS	SALLY	20 JUL-22 JUL	3	40	989	300	9	0	126
06	TD	----	28 JUL-30 JUL	3	30	993	180	13	0	826
07	TD	----	01 AUG-02 AUG	2	30	1001	180	5	0	423
08	TS	THERESE	01 AUG-03 AUG	3	40	988	120	5	0	993
09	TS	VIOLET	05 AUG-09 AUG	5	40	990	420	14	0	770
10	T	WILDA	08 AUG-15 AUG	8	105	939	540	27	19	1,860
11	T	ANITA	15 AUG-22 AUG	8	135	912	480	26	19	2,001
12	T	BILLIE	23 AUG-31 AUG	9	110	946	600	34	24	1,697
13	T	CLARA	24 AUG-03 SEP	11	85	965	420	34	13	2,449
14	H	DOT	(NAME GIVEN TO CENTRAL PACIFIC HURRICANE CENTER, HONOLULU)							
15	TS	ELLEN	03 SEP-05 SEP	3	40	984	180	9	0	1,206
16	TS	FRAN	04 SEP-07 SEP	4	55	976	300	15	0	1,731
17	T	GEORGIA	07 SEP-14 SEP	8	140	904	420	26	19	1,718
18	T	HOPE	19 SEP-29 SEP	11	150	895	360	37	27	3,034
19	T	IRIS	03 OCT-08 OCT	6	100	944	180	18	11	492
20	TD	----	04 OCT	1	30	1006	150	4	0	60
21	T	JOAN	09 OCT-18 OCT	10	150	901	720	34	25	2,254
22	T	KATE	14 OCT-25 OCT	12	130	938	540	42	34	2,317
23	TS	LOUISE	26 OCT-28 OCT	3	60	978	360	9	0	633
24	TS	MARGE	27 OCT-06 NOV	11	55	987	240	32	0	1,239
25	TS	NORA	31 OCT-03 NOV	4	50	1002	240	6	0	377
26	TS	OPAL	10 NOV-17 NOV	8	50	991	180	14	0	773
27	T	PATSY	14 NOV-22 NOV	9	135	918	600	33	19	2,917
28	TS	RUTH	24 NOV-29 NOV	6	40	995	240	3	0	391
		1970 TOTALS		175				533	251	

*Data Taken From Best Track

TABLE 4-6

1970 TROPICAL STORM AND DEPRESSION POSITION DATA

TROPICAL STORM PAMELA
29 JUN - 1 JUL

WARNING NO.	DTG	WARNING POSIT LAT	WARNING POSIT LONG	BEST TRACK LAT	BEST TRACK LONG	24 HOUR FORECAST POSIT LAT	24 HOUR FORECAST POSIT LONG
01	29/0500Z	7.1N	127.7E	7.7N	127.7E	7.8N	126.6E
02	29/1100Z	7.6N	127.3E	8.4N	127.6E	8.6N	126.3E
03	29/1700Z	8.9N	127.2E	9.2N	127.0E	11.3N	126.3E
04	29/2300Z	10.0N	126.0E	9.9N	125.9E	12.5N	122.8E
05	30/0500Z	10.4N	124.9E	10.3N	125.1E	12.5N	121.5E
06	30/1100Z	10.7N	124.3E	10.7N	124.4E	-	-

TROPICAL STORM RUBY
11 JUL - 16 JUL

WARNING NO.	DTG	WARNING POSIT LAT	WARNING POSIT LONG	BEST TRACK LAT	BEST TRACK LONG	24 HOUR FORECAST POSIT LAT	24 HOUR FORECAST POSIT LONG
01	11/2300Z	9.7N	128.5E	8.1N	131.3E	10.8N	125.5E
02	12/0500Z	10.0N	127.7E	9.2N	128.7E	11.1N	124.7E
03	12/1100Z	10.7N	127.2E	10.3N	127.8E	12.7N	124.7E
04	12/1700Z	11.5N	126.9E	12.7N	126.4E	13.9N	124.8E
05	12/2300Z	14.1N	125.8E	13.9N	125.8E	17.7N	122.2E
06	13/0500Z	14.9N	124.5E	14.7N	124.7E	18.6N	120.7E
07	13/1100Z	15.8N	123.4E	16.0N	123.8E	19.6N	120.1E
08	13/1700Z	17.4N	122.2E	17.2N	122.8E	21.8N	119.5E
09	13/2300Z	18.2N	121.9E	18.2N	121.5E	23.3N	119.7E
10	14/0500Z	19.5N	120.9E	18.7N	120.5E	24.3N	119.5E
11	14/1100Z	19.0N	118.2E	18.7N	119.3E	20.7N	116.3E
12	14/1700Z	19.4N	117.8E	19.2N	118.3E	20.9N	115.9E
13	14/2300Z	19.9N	117.7E	19.8N	117.6E	21.6N	115.3E
14	15/0500Z	20.2N	116.9E	20.2N	116.7E	22.2N	114.0E
15	15/1100Z	20.8N	116.3E	20.8N	116.0E	22.8N	112.8E
16	15/1700Z	21.3N	115.5E	21.3N	115.5E	23.1N	112.0E
17	15/2300Z	21.7N	114.8E	21.9N	115.0E	24.0N	111.5E
18	16/0500Z	23.1N	114.6E	22.6N	114.8E	-	-

TROPICAL STORM SALLY
20 JUL - 22 JUL

WARNING NO.	DTG	WARNING POSIT LAT	WARNING POSIT LONG	BEST TRACK LAT	BEST TRACK LONG	24 HOUR FORECAST POSIT LAT	24 HOUR FORECAST POSIT LONG
01	20/0500Z	26.2N	161.9E	26.0N	162.2E	28.5N	164.6E
02	20/1100Z	26.8N	162.3E	26.8N	162.5E	29.1N	163.9E
03	20/1700Z	26.7N	162.9E	27.7N	162.6E	28.5N	165.9E
04	20/2300Z	28.5N	162.8E	28.6N	162.7E	34.8N	163.9E
05	21/0500Z	29.8N	162.6E	29.8N	162.6E	35.8N	164.6E
06	21/1100Z	31.7N	162.5E	31.1N	162.3E	-	-
07	21/1700Z	32.6N	161.7E	32.2N	161.7E	33.8N	158.0E
08	21/2300Z	33.2N	160.8E	33.1N	161.2E	33.7N	157.3E
09	22/0500Z	34.9N	161.1E	34.7N	161.1E	-	-

TROPICAL DEPRESSION 06
28 JUL - 31 JUL

WARNING NO.	DTG	WARNING POSIT LAT	WARNING POSIT LONG	BEST TRACK LAT	BEST TRACK LONG	24 HOUR FORECAST POSIT LAT	24 HOUR FORECAST POSIT LONG
01	28/0500Z	26.2N	136.3E	26.3N	136.3E	27.1N	130.5E
02	28/1100Z	26.4N	134.7E	26.8N	135.3E	27.2N	129.4E
03	28/1700Z	26.6N	133.6E	27.3N	134.4E	27.3N	128.9E
04	28/2300Z	27.6N	133.5E	27.7N	133.3E	29.5N	129.7E
05	29/0500Z	28.1N	132.5E	27.9N	132.3E	29.8N	129.1E
06	29/1100Z	28.3N	131.3E	28.2N	131.5E	29.6N	128.2E
07	29/1700Z	28.5N	131.0E	28.5N	131.1E	29.7N	128.2E
08	29/2300Z	29.0N	130.9E	29.2N	130.7E	30.0N	131.0E
09	30/0500Z	30.1N	130.6E	29.8N	130.5E	33.0N	131.2E
10	30/1100Z	30.7N	130.5E	30.3N	130.3E	33.8N	131.6E
11	30/1700Z	30.8N	130.1E	30.6N	129.6E	-	-
12	30/2300Z	30.2N	129.1E	30.6N	128.8E	34.2N	129.5E
13	31/0500Z	31.2N	128.4E	-	-	-	-

TROPICAL DEPRESSION 07
1 AUG - 2 AUG

WARNING NO.	DTG	WARNING POSIT LAT	WARNING POSIT LONG	BEST TRACK LAT	BEST TRACK LONG	24 HOUR FORECAST POSIT LAT	24 HOUR FORECAST POSIT LONG
01	01/0500Z	21.5N	123.0E	21.5N	122.8E	22.1N	121.9E
02	01/1100Z	21.9N	121.1E	21.7N	121.6E	23.8N	117.3E

TROPICAL DEPRESSION 07 (Cont'd)
1 AUG - 2 AUG

WARNING NO.	DTG	WARNING POSIT LAT	WARNING POSIT LONG	BEST TRACK LAT	BEST TRACK LONG	24 HOUR FORECAST POSIT LAT	24 HOUR FORECAST POSIT LONG
03	01/1700Z	22.3N	120.3E	22.3N	120.3E	24.3N	116.6E
04	01/2300Z	23.0N	118.8E	22.9N	118.7E	-	-
05	02/0500Z	23.4N	117.0E	23.4N	117.0E	-	-

TROPICAL STORM THERESE
2 AUG - 3 AUG

WARNING NO.	DTG	WARNING POSIT LAT	WARNING POSIT LONG	BEST TRACK LAT	BEST TRACK LONG	24 HOUR FORECAST POSIT LAT	24 HOUR FORECAST POSIT LONG
01	02/2300Z	34.9N	165.5E	34.4N	165.5E	44.3N	169.2E
02	03/0500Z	37.2N	165.6E	37.2N	166.2E	-	-
03	03/1100Z	39.0N	167.5E	39.7N	167.9E	-	-
04	03/1700Z	41.2N	169.6E	42.2N	169.8E	-	-
05	03/2300Z	44.6N	171.0E	44.6N	170.9E	-	-

TROPICAL STORM VIOLET
5 AUG - 9 AUG

WARNING NO.	DTG	WARNING POSIT LAT	WARNING POSIT LONG	BEST TRACK LAT	BEST TRACK LONG	24 HOUR FORECAST POSIT LAT	24 HOUR FORECAST POSIT LONG
01	05/2300Z	15.7N	124.0E	15.0N	124.0E	17.0N	123.3E
02	06/0500Z	15.2N	123.6N	15.3N	123.6E	16.8N	123.0E
03	06/1100Z	15.7N	123.4E	15.7N	123.4E	17.0N	122.2E
04	06/1700Z	15.8N	123.1E	16.1N	122.6E	17.4N	121.8E
05	06/2300Z	16.6N	122.0E	16.6N	121.9E	18.7N	120.0E
06	07/0500Z	17.7N	121.0E	17.7N	120.9E	20.1N	117.7E
07	07/1100Z	18.3N	120.0E	17.9N	119.6E	20.6N	116.1E
08	07/1700Z	18.6N	118.7E	18.6N	118.7E	20.8N	114.1E
09	07/2300Z	19.2N	117.5E	19.3N	117.5E	21.3N	112.6E
10	08/0500Z	19.6N	116.7E	19.7N	116.8E	21.5N	112.2E
11	08/1100Z	20.2N	115.7E	20.3N	115.7E	21.8N	111.1E
12	08/1700Z	20.7N	114.6E	20.8N	114.6E	22.1N	110.0E
13	08/2300Z	21.1N	113.6E	21.1N	113.6E	-	-
14	09/0500Z	21.7N	112.5E	21.7N	112.5E	-	-

TROPICAL STORM ELLEN
3 SEP - 5 SEP

WARNING NO.	DTG	WARNING POSIT LAT	WARNING POSIT LONG	BEST TRACK LAT	BEST TRACK LONG	24 HOUR FORECAST POSIT LAT	24 HOUR FORECAST POSIT LONG
01	04/0500Z	23.5N	135.7E	22.9N	136.1E	25.8N	132.0E
02	04/1100Z	24.3N	134.6E	24.1N	134.7E	26.8N	128.7E
03	04/1700Z	25.2N	133.2E	25.3N	133.0E	27.1N	127.0E
04	04/2300Z	26.3N	130.5E	26.3N	130.5E	27.4N	122.2E
05	05/0500Z	26.5N	128.2E	26.3N	128.0E	-	-
06	05/1100Z	25.7N	125.5E	25.7N	125.5E	-	-
07	05/1700Z	24.1N	124.8E	24.2N	124.9E	-	-
08	05/2300Z	24.0N	125.8E	24.5N	125.7E	-	-

TROPICAL STORM FRAN
4 SEP - 7 SEP

WARNING NO.	DTG	WARNING POSIT LAT	WARNING POSIT LONG	BEST TRACK LAT	BEST TRACK LONG	24 HOUR FORECAST POSIT LAT	24 HOUR FORECAST POSIT LONG
01	04/1100Z	20.6N	127.2E	20.6N	127.7E	20.6N	125.1E
02	04/1700Z	20.6N	126.6E	20.9N	128.6E	20.6N	124.5E
03	04/2300Z	21.7N	129.5E	21.7N	129.5E	25.1N	130.7E
04	05/0500Z	23.0N	130.0E	22.9N	130.1E	27.7N	128.9E
05	05/1100Z	24.4N	130.5E	24.2N	130.0E	27.2N	129.4E
06	05/1700Z	25.5N	128.9E	25.6N	128.8E	23.5N	126.1E
07	05/2300Z	26.5N	126.7E	26.5N	126.7E	27.2N	122.7E
08	06/0500Z	25.9N	124.9E	26.2N	124.7E	27.0N	123.1E
09	06/1100Z	26.3N	122.3E	25.9N	123.0E	-	-
10	06/1700Z	26.2N	121.2E	25.3N	121.8E	-	-
11	06/2300Z	24.8N	120.7E	24.9N	120.8E	-	-
12	07/0500Z	24.8N	120.2E	24.8N	120.1E	-	-
13	07/1100Z	24.8N	119.4E	24.8N	119.5E	-	-
14	07/1700Z	24.9N	119.0E	25.0N	118.9E	-	-
15	07/2300Z	25.4N	118.5E	25.2N	118.3E	-	-

TROPICAL DEPRESSION 20
4 SEP

WARNING NO.	DTG	WARNING POSIT LAT	WARNING POSIT LONG	BEST TRACK LAT	BEST TRACK LONG	24 HOUR FORECAST POSIT LAT	24 HOUR FORECAST POSIT LONG
01	04/0500Z	10.0N	151.0E			11.7N	147.3E
02	04/1100Z	10.5N	150.1E			11.9N	146.3E

TROPICAL DEPRESSION 20 (Cont'd)
4 SEP

WARNING NO.	DTG	WARNING POSIT LAT	WARNING POSIT LONG	BEST TRACK LAT	BEST TRACK LONG	24 HOUR FORECAST POSIT LAT	24 HOUR FORECAST POSIT LONG
03	04/1700Z	10.9N	149.3E			12.1N	145.9E
04	04/2300Z	10.5N	149.0E			-	-

TROPICAL STORM MARGE
27 OCT - 6 NOV

WARNING NO.	DTG	WARNING POSIT LAT	WARNING POSIT LONG	BEST TRACK LAT	BEST TRACK LONG	24 HOUR FORECAST POSIT LAT	24 HOUR FORECAST POSIT LONG
01	28/0500Z	12.2N	142.2E	12.2N	142.0E	13.6N	137.5E
02	28/1100Z	12.5N	140.6E	12.4N	140.7E	13.1N	135.4E
03	28/1700Z	12.4N	139.3E	12.5N	139.2E	12.8N	134.4E
04	28/2300Z	12.6N	137.5E	12.7N	137.5E	12.8N	131.7E
05	29/0500Z	13.8N	135.7E	13.3N	136.7E	15.5N	129.3E
06	29/1100Z	13.3N	134.3E	13.3N	134.3E	-	-
07	30/1100Z	14.7N	130.5E	14.9N	130.2E	14.9N	128.4E
08	30/1700Z	14.8N	130.0E	15.2N	129.2E	14.9N	127.8E
09	30/2300Z	14.7N	127.8E	15.4N	128.1E	14.4N	122.9E
10	31/0500Z	15.6N	127.1E	15.5N	127.1E	16.5N	123.1E
11	31/1100Z	15.0N	125.6E	15.0N	125.6E	13.4N	120.2E
12	31/1700Z	14.4N	124.2E	14.3N	124.3E	-	-
13	31/2300Z	13.7N	122.9E	13.9N	123.1E	-	-
14	01/0500Z	13.7N	122.1E	13.7N	122.1E	-	-
15	02/0500Z	14.1N	118.1E	14.1N	118.4E	13.3N	115.2E
16	02/1100Z	14.1N	117.8E	14.2N	117.8E	14.1N	115.2E
17	02/1700Z	14.5N	116.9E	14.6N	117.2E	14.5N	113.9E
18	02/2300Z	14.7N	116.9E	14.7N	116.9E	15.2N	115.0E
19	03/0500Z	14.8N	116.6E	14.8N	116.8E	15.0N	114.8E
20	03/1100Z	14.9N	116.8E	14.4N	116.5E	14.7N	115.5E
21	03/1700Z	14.3N	116.4E	14.4N	116.5E	13.7N	114.6E
22	03/2300Z	14.3N	116.3E	14.4N	116.5E	13.6N	114.8E
23	04/0500Z	14.5N	116.6E	14.9N	116.3E	14.5N	116.6E
24	04/1100Z	15.3N	115.8E	15.3N	115.7E	17.2N	115.7E
25	04/1700Z	15.7N	115.0E	15.8N	115.0E	16.2N	112.1E
26	04/2300Z	15.9N	114.3E	15.7N	114.5E	16.2N	111.3E
27	05/0500Z	15.8N	114.5E	15.5N	114.5E	15.8N	113.9E
28	05/1100Z	15.4N	114.6E	15.6N	114.7E	15.4N	114.0E
29	05/1700Z	15.7N	114.0E	15.8N	113.9E	15.4N	112.7E
30	05/2300Z	15.8N	113.6E	15.8N	113.5E	15.3N	112.0E
31	06/0500Z	15.7N	112.8E	15.9N	112.9E	-	-
32	06/1100Z	16.1N	112.4E	16.1N	112.5E	-	-

TROPICAL STORM LOUISE
27 OCT - 29 OCT

WARNING NO.	DTG	WARNING POSIT LAT	WARNING POSIT LONG	BEST TRACK LAT	BEST TRACK LONG	24 HOUR FORECAST POSIT LAT	24 HOUR FORECAST POSIT LONG
01	27/0500Z	11.7N	115.5E	11.8N	115.5E	12.0N	111.0E
02	27/1100Z	12.1N	114.4E	12.1N	114.4E	12.3N	110.1E
03	27/1700Z	12.3N	113.5E	12.3N	112.9E	12.3N	109.4E
04	27/2300Z	12.5N	111.6E	12.3N	111.5E	-	-
05	28/0500Z	12.2N	109.9E	11.9N	110.3E	-	-
06	28/1100Z	11.7N	109.4E	11.6N	109.5E	-	-
07	28/1700Z	11.3N	108.5E	11.2N	108.5E	-	-
08	28/2300Z	11.0N	107.5E	10.9N	107.5E	-	-
09	29/0500Z	11.3N	106.5E	-	-	-	-

TROPICAL STORM NORA
2 NOV - 3 NOV

WARNING NO.	DTG	WARNING POSIT LAT	WARNING POSIT LONG	BEST TRACK LAT	BEST TRACK LONG	24 HOUR FORECAST POSIT LAT	24 HOUR FORECAST POSIT LONG
01	02/0500Z	7.8N	107.0E	8.8N	107.1E	7.8N	103.5E
02	02/1100Z	7.8N	106.1E	7.8N	106.3E	7.9N	102.9E
03	02/1700Z	7.8N	105.6E	7.8N	105.6E	7.9N	102.9E
04	02/2300Z	7.8N	104.9E	7.8N	104.9E	7.9N	102.2E
05	03/0500Z	7.8N	104.2E	7.9N	104.4E	8.1N	101.4E
06	03/1100Z	8.0N	103.8E	8.1N	103.8E	-	-

TROPICAL STORM OPAL
13 NOV - 17 NOV

WARNING NO.	DTG	WARNING POSIT LAT	WARNING POSIT LONG	BEST TRACK LAT	BEST TRACK LONG	24 HOUR FORECAST POSIT LAT	24 HOUR FORECAST POSIT LONG
01	13/2300Z	15.1N	118.2E	15.1N	118.2E	15.4N	115.3E
02	14/0500Z	15.4N	117.2E	15.4N	117.3E	15.2N	113.7E
03	14/1100Z	15.6N	116.4E	15.6N	116.3E	15.1N	113.4E
04	14/1700Z	15.6N	115.5E	15.7N	115.3E	14.8N	112.6E
05	14/2300Z	15.4N	114.3E	15.5N	114.5E	14.3N	111.0E
06	15/0500Z	15.5N	114.4E	15.2N	114.1E	15.2N	112.8E
07	15/1100Z	14.6N	113.3E	14.7N	113.2E	13.1N	109.9E
08	15/1700Z	14.3N	112.7E	14.3N	112.5E	13.0N	109.7E
09	15/2300Z	13.8N	111.8E	13.7N	111.9E	12.7N	108.3E
10	16/0500Z	12.8N	111.3E	12.8N	111.4E	10.9N	108.2E
11	16/1100Z	11.8N	111.0E	11.8N	110.8E	9.0N	108.1E
12	16/1700Z	10.8N	110.5E	10.8N	110.2E	8.5N	107.8E
13	16/2300Z	9.9N	109.3E	9.9N	109.1E	-	-
14	17/0500Z	9.4N	107.8E	9.4N	107.9E	-	-

TROPICAL STORM RUTH
24 NOV - 29 NOV

WARNING NO.	DTG	WARNING POSIT LAT	WARNING POSIT LONG	BEST TRACK LAT	BEST TRACK LONG	24 HOUR FORECAST POSIT LAT	24 HOUR FORECAST POSIT LONG
01	27/0500Z	8.7N	108.5E	8.8N	108.4E	8.2N	105.7E
02	27/1100Z	8.2N	107.7E	8.5N	107.2E	7.2N	104.6E
03	27/1700Z	7.8N	106.5E	8.4N	106.1E	-	-

Forecast positions for the 24, 48, and 72 hour forecasts are verified only as long as the best track analysis estimates winds in excess of 33 knots for tropical cyclones which reach typhoon intensity.

In addition to this method of verifying absolute error distance, a computation of closest distance to the best track (right angle error) has been included to indicate the demonstrated ability to forecast the path of motion without regard to speed.

The following tables and figures are presented to graphically depict the distribution of forecasting error in JTWC forecasts.

FORECAST VERIFICATION
AVERAGE ERROR (NAUTICAL MILES)

	24 HR	48 HR	72 HR
1950-58	170	---	---
1959	*117	*267	---
1960	177	354	---
1961	136	274	---
1962	144	287	476
1963	127	246	374
1964	133	284	429
1965	151	303	418
1966	136	280	432
1967	125	276	414
1968	105	229	337
1969	111	237	349
1970	98	181	272

*FORECAST POSITIONS NORTH OF 35N WERE NOT VERIFIED.

TABLE 4-7

JTWC OFFICIAL FORECAST ACCURACY

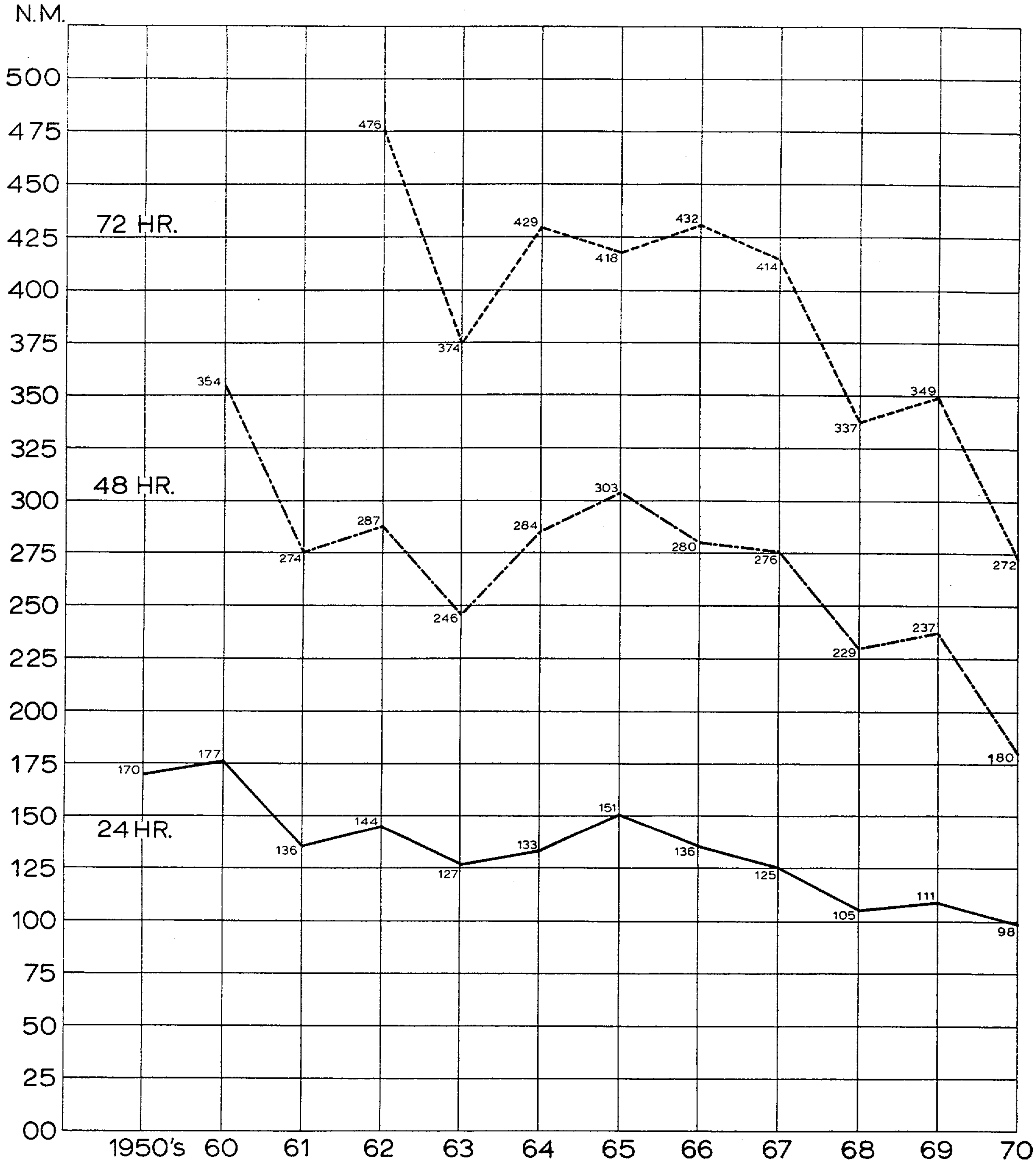


FIGURE 4-1

JOINT TYPHOON WARNING CENTER ERROR SUMMARY

(Average errors are given in nautical miles)

	CYCLONE	WRNG POSIT ERROR	# WRNGS	24 HR FCST ERROR	24 HR RT ANGLE ERROR	24 HR # CASES	48 HR FCST ERROR	48 HR RT ANGLE ERROR	48 HR # CASES	72 HR FCST ERROR	72 HR RT ANGLE ERROR	72 HR # CASES
1.	T. NANCY	14	31	85	67	27	190	128	23	322	166	10
2.	T. OLGA	14	29	88	62	25	139	88	20	312	232	8
3.	T.S. PAMELA	22	6	165	--	2	---	---	--	---	---	--
4.	T.S. RUBY	31	18	124	--	14	331	---	6	228	---	1
5.	T.S. SALLY	24	9	182	--	5	---	---	--	---	---	--
6.	T.D.	24	13	99	--	8	---	---	--	---	---	--
7.	T.D.	10	5	276	--	1	---	---	--	---	---	--
8.	T.S. THERESE	37	5	72	--	1	---	---	--	---	---	--
9.	T.S. VIOLET	12	14	84	--	10	217	---	5	---	---	--
10.	T. WILDA	18	27	146	77	23	290	243	18	512	446	7
11.	T. ANITA	19	26	100	41	22	202	88	16	323	136	6
12.	T. BILLIE	16	34	85	62	30	169	151	22	315	232	9
13.	T. CLARA	20	34	154	100	29	249	179	6	432	400	1
14.	H. DOT	(CENTRAL PACIFIC HURRICANE CENTER)										
15.	T.S. ELLEN	16	9	214	--	4	---	---	--	---	---	--
16.	T.S. FRAN	25	15	269	--	8	454	---	6	438	---	2
17.	T. GEORGIA	15	26	69	43	22	114	82	17	116	85	6
18.	T. HOPE	16	37	101	85	32	204	167	24	242	185	9
19.	T. IRIS	15	18	90	50	14	251	89	7	306	290	1
20.	T.D.	30	4	---	--	--	---	---	--	---	---	--
21.	T. JOAN	20	34	99	56	30	168	103	26	151	67	10
22.	T. KATE	14	42	88	53	38	192	119	34	284	182	15
23.	T.S. LOUISE	13	9	54	--	3	---	---	--	---	---	--
24.	T.S. MARGE	16	32	100	--	24	202	---	10	256	---	4
25.	T.S. NORA	16	6	48	--	2	---	---	--	---	---	--
26.	T.S. OPAL	10	14	81	--	10	194	---	5	---	---	--
27.	T. PATSY	22	33	61	38	27	101	41	23	166	53	10
28.	T.S. RUTH	26	3	66	--	2	150	---	2	---	---	--
	ALL FORECASTS	17.7	533	104	--	413	190	---	270	279	---	99
	TYPHOONS	17.0	371	98	63	314	181	121	232	272	177	89

TABLE 4-8

LATITUDE STRATIFICATION OF 1970 FORECAST ERRORS

	CASES	MEAN ERROR (N.M.)
24 Hour		
Whole Sample	314	98
Below 20N	158	84
20N-30N	84	88
Below 30N	242	85
Above 30N	72	139
48 Hour		
Whole Sample	232	181
Below 20N	119	157
20N-30N	69	207
Below 30N	188	175
Above 30N	44	206
72 Hour		
Whole Sample	89	272
Below 20N	46	221
20N-30N	24	306
Below 30N	70	250
Above 30N	19	352

TABLE 4-9

INDIVIDUAL TYPHOONS
OF 1970
24 HOUR VERIFICATION ERROR

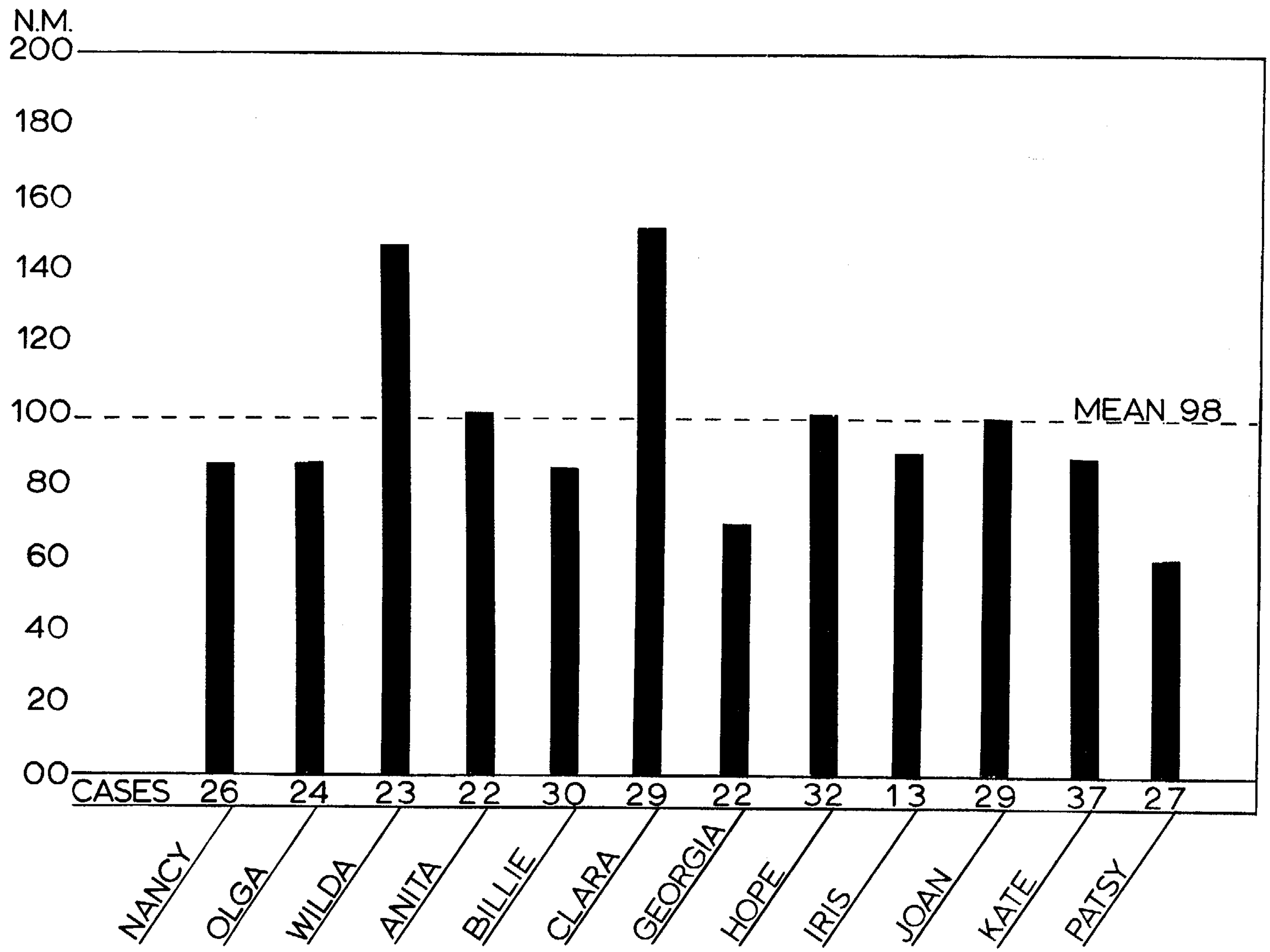


FIGURE 4-2

RIGHT ANGLE ERROR

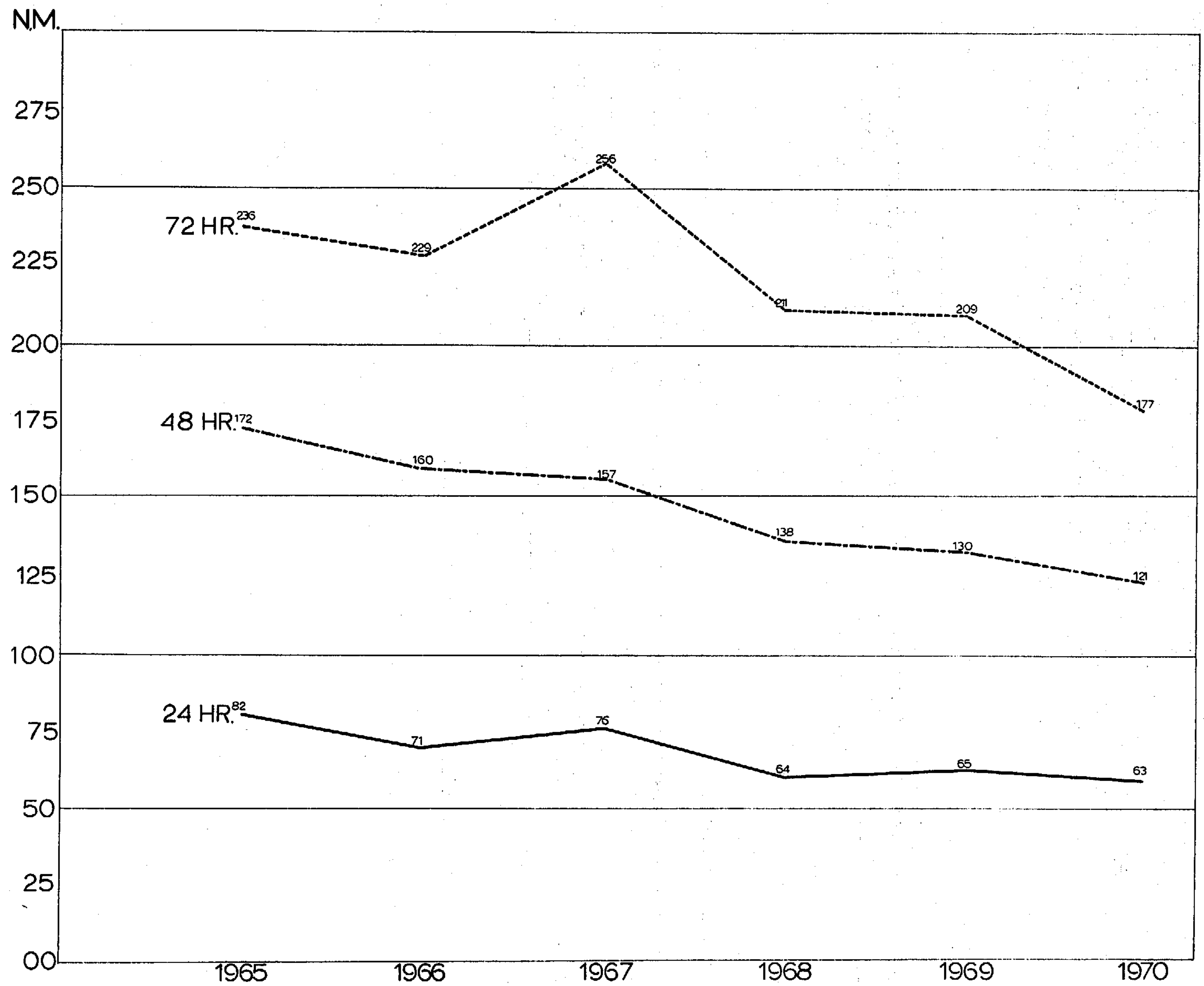


FIGURE 4-3

CONFIDENCE FORECASTING

Confidence forecasts were authorized for use during 1970. When a 24 hour vector error of over 130 miles was anticipated, a remark to this effect was included in the warning. The background and development of this method of confidence forecasting is covered in the 1969 Annual Typhoon Report (FWC/JTWC, 1969). It is felt that the use of this method of providing the user a feel for the forecaster's confidence in a particular forecast was quite useful and meaningful. Confidence statements were used 41 times during the year. Of those that verified, 25 or 68% verified with 24 hour errors over 130 miles. During the experimental stage of using this technique in 1969 (FWC/JTWC, 1969), only 47% verified. It may be that through experience and concentration, skill in recognizing the large error situations is improved.

A graphic evaluation of the results of using confidence forecasts during 1970 is contained in Figure 4-4. This graph portrays comparative cumulative percentage curves of the resultant average vector errors for normal forecasts vs. low confidence forecasts. The percentile error values for the low confidence forecasts are nearly twice those of average forecasts. Obviously all large error forecasts cannot be recognized but the data indicate that when one is recognized it is wise to include a larger margin of error in disaster preparedness planning or evasionary tactics.

These confidence forecasts will continue to be issued during 1971. Attempt will be made in-house during 1971 to refine and expand confidence forecasting in order to make them ever more meaningful and applicable to the 48 and 72 hour extended outlooks also.

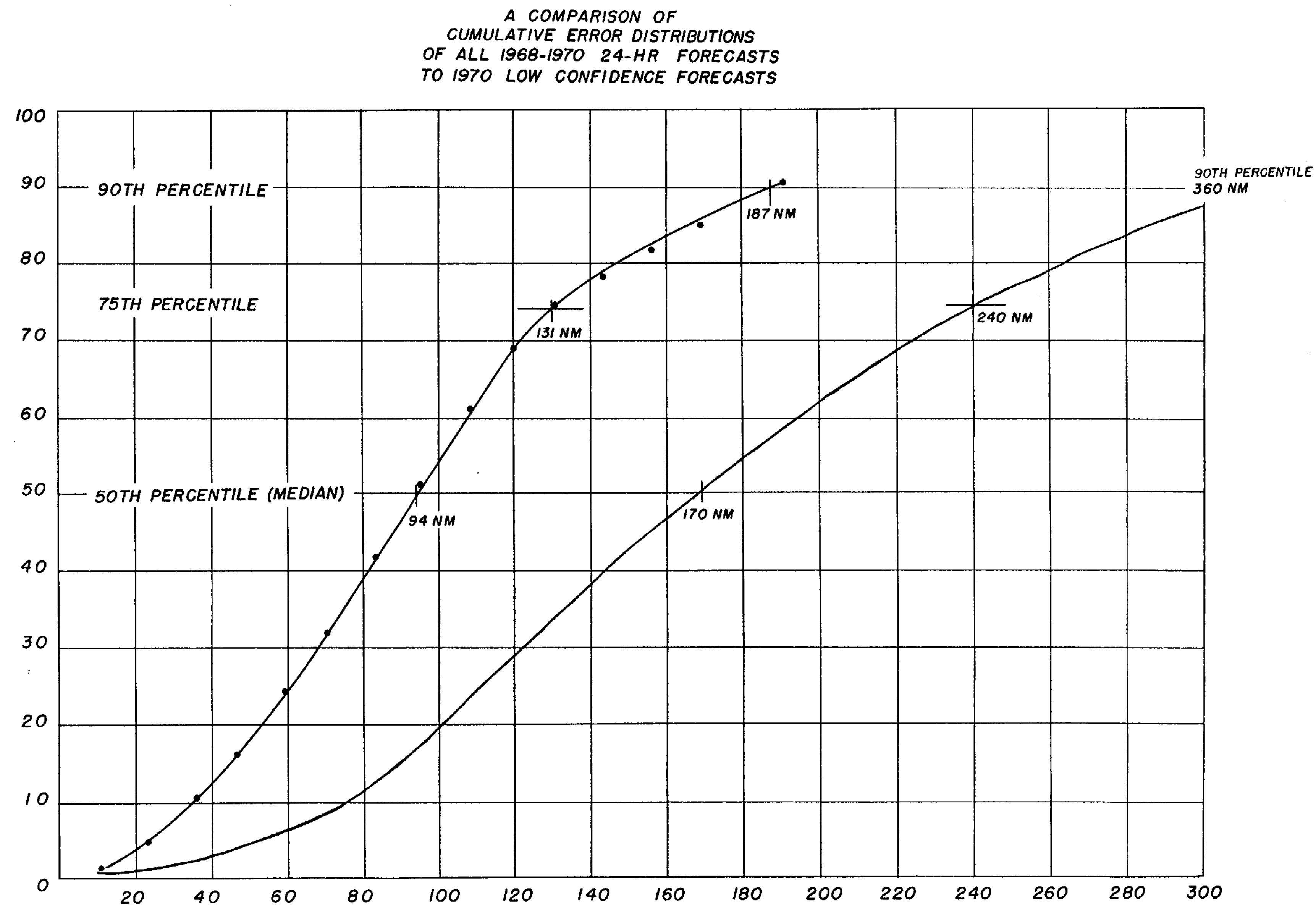

A COMPARISON OF
CUMULATIVE ERROR DISTRIBUTIONS
OF ALL 1968-1970 24-HR FORECASTS
TO 1970 LOW CONFIDENCE FORECASTS
100
90
80
70
60
50
40
30
20
10
0
90TH PERCENTILE
75TH PERCENTILE
50TH PERCENTILE (MEDIAN)
187 NM
131 NM
94 NM
240 NM
170 NM
90TH PERCENTILE
360 NM
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

FIGURE 4-4

SUMMARY OF TROPICAL CYCLONE FORMATION ALERTS 1970

Early in 1970 CINCPAC authorized the use of the Tropical Cyclone Formation Alert message. This new message enabled JTWC to provide a form of warning in those situations in which significant tropical cyclone development was possible, but had not already taken place based on observational evidence.

During 1970 there were 32 tropical disturbances for which formation alerts were issued (Hurricane Dot excluded.) The total number of alerts, including extensions, was 57.

In summary,

1. Alerts were issued for 18 out of 27 numbered tropical cyclones.

a. Nine were superceded by tropical depression warnings.

b. Nine were superceded by tropical storm warnings.

2. Out of the 32 alert systems, 18 or 56% developed into tropical cyclones.*

3. Alerts by months.

J	F	M	A	M	J	J	A	S	O	N	D
0	1	3	1	0	2	3	7	5	4	5	1

*Typhoon Patsy and Tropical Storm Ruth each had two series of alerts issued prior to the initial tropical cyclone warning.

REFERENCES:

Green, R. A., "The Weather and Circulation of July 1970--Variable Weather Ending in a Period of High Air Pollution in the East, Persistently Warm in the Southwest," Monthly Weather Review Vol. 98, No. 10, October 1970, pp789-790.

Sadler, J. C., "The Tropical Upper Tropospheric Trough as a Secondary Source of Typhoons and a Primary Source of Trade-wind Disturbances," Hawaii Institute of Geophysics, University of Hawaii, Final Report to Air Force Cambridge Research Laboratories on Contract No. AF19(628)-3860, Bedford, Mass., March 1967, 44pp.

Simpson, R. H., "A Reassessment of the Hurricane Prediction Problem," ESSA Technical Memorandum WBTM SR-50, February 1971, 16pp.

Sugg, A. L., and P. J. Herbert, "The Atlantic Hurricane Season of 1968," Monthly Weather Review Vol. 97, No. 3, March 1969, p227.

CHAPTER 5

INDIVIDUAL TYPHOONS OF 1970

NOTE. See last page of this chapter for definition of units and terms appearing herein.

A. TYPHOON NANCY 19 FEB 2300Z-27 FEB 1100Z*

1. STATISTICS

a. Number of Warnings Issued - 31

b. Number of Warnings with Typhoon Intensity - 19

c. Distance Traveled During Warning Period - 2,148 MI

2. CHARACTERISTICS AS A TYPHOON

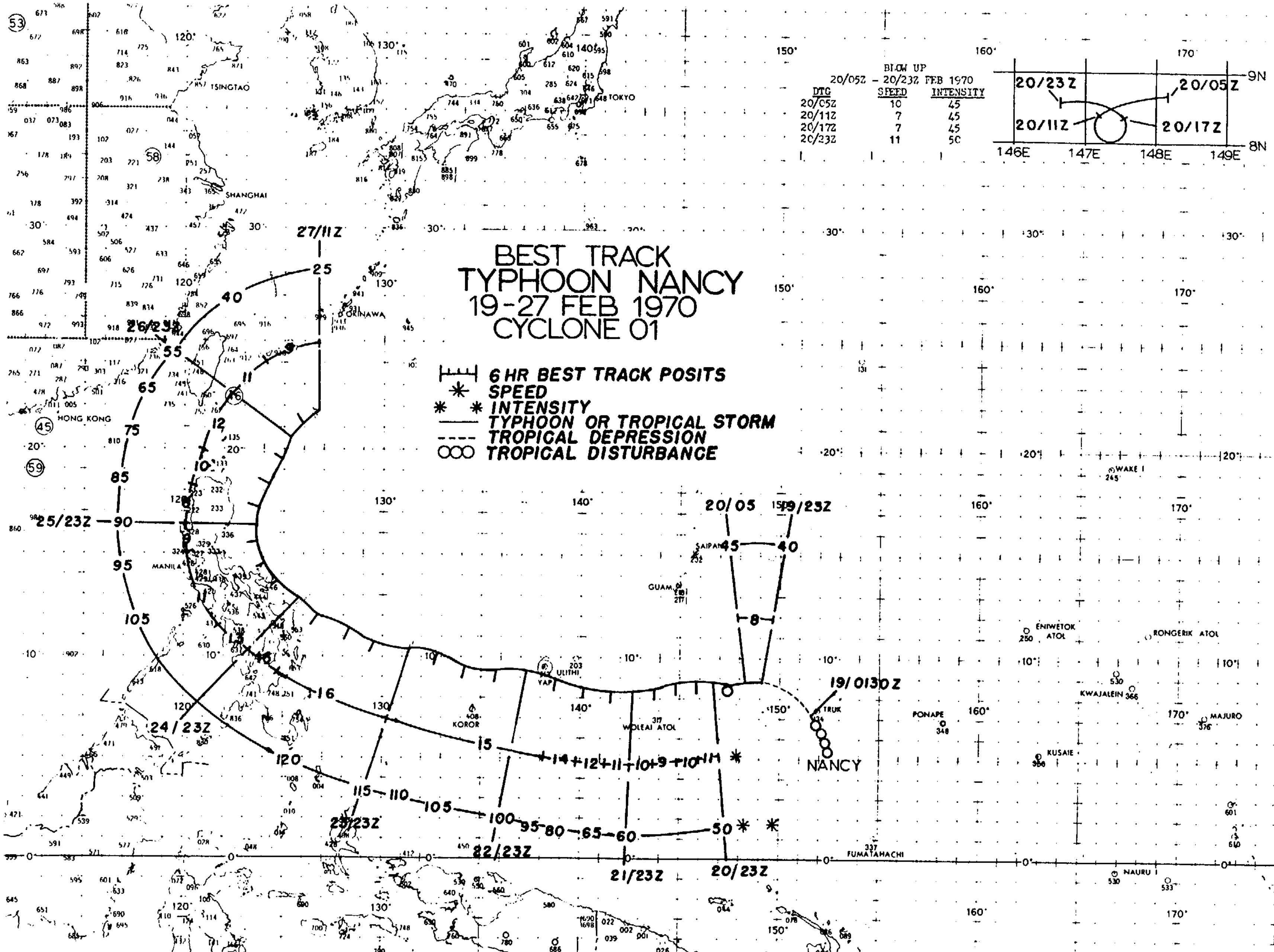
a. Minimum Observed SLP - 949 MBS at 24/0900Z

b. Minimum Observed 700 MB Height - 2606 M at 24/2100Z

c. Maximum Surface Wind - 120 KTS (From Best Track)

d. Maximum Radius of Surface Circulation - 400 MI

*Time of First and Last Warning Issued (Followed throughout Chapter 5.)


BEST TRACK
TYPHOON NANCY
19-27 FEB 1970
CYCLONE 01
6 HR BEST TRACK POSITS
SPEED
INTENSITY
TYPHOON OR TROPICAL STORM
TROPICAL DEPRESSION
TROPICAL DISTURBANCE
BLOW UP
20/05Z - 20/23Z FEB 1970
DTG SPEED INTENSITY
20/05Z 10 45
20/11Z 7 45
20/17Z 7 45
20/23Z 11 50
20/23Z
20/05Z
20/11Z
20/17Z
9N
8N
146E
147E
148E
149E
19/0130Z
20/05
19/23Z
20/23Z
21/23Z
22/23Z
23/23Z
24/23Z
25/23Z
26/23Z
27/11Z
NANCY
TOKYO
TSINGTAO
SHANGHAI
OKINAWA
HONG KONG
MANILA
SAIPAN
GUAM
ULITHI
YAP
KOROR
WOLEAI ATOL
TRUK
PONAPE
KUSAIE
ENIWETOK ATOL
RONGERIK ATOL
KWAJALEIN
MAJURO
WAKE I
NAURU I
FUMATAHACHI

3. TYPHOON NANCY NARRATIVE

On the 18th of February a mass of increased convective activity showing signs of organization was noted south of the Central Carolines by the ESSA-8 Satellite. A recon aircraft was dispatched to the area the following day finding a weak circulation with a 1004 mb central pressure and thus the birth of Nancy was detected just south of Truk Island.

For several days prior to the 18th, satellite pictures had shown active ITCZ cloudiness in the region between the Central Carolines and the equator. During this period a front advanced into the tropics, producing a tightening pressure gradient across the Caroline chain and increasing the horizontal shear. It is believed that this increase provided the impetus for development of a weak perturbation located in the intertropical trough. This situation is similar to events described by Fett (1968) for generation of Typhoon Marie in 1966.

The developing Nancy drifted northwestward and reached tropical storm intensity early on the 20th. Swinging on a westerly track at 10 to 12 knots, it passed through the Caroline chain as it reacted to an east-west oriented ridge line to its north. Typhoon intensity was reached mid-day of the 22nd (Figure 5-1), about 100 miles northwest of Woleai Atoll, as Nancy moved from beneath a weak 200 mb trough which had been an inhibiting feature to outflow aloft from the storm.

Development of typhoon strength is unusual for a tropical storm during February. For the past 25 year period of record only one other storm (Irma, 1953) achieved this mark.

The eye of Nancy passed 35 miles south of Yap early the following morning with the island experiencing winds of 60 knots gusting to 69 knots and a barometer reading of 988.4 mb. Fortunately, the wall cloud region did not cross over Yap, as the storm at that time had reached 95 knots in intensity. A reconnaissance aircraft shortly afterward reported a circular eye 25 miles in diameter and a central pressure of 958 mb.

Damage on Yap was estimated to be $160,000 with no personal casualties. Major damage was caused by heavy sea action and rains resulting in erosion of roads and causeways and damage to crops and homes.

Upon movement into the Philippine Sea at a rate of 15 to 16 knots, the typhoon approached the southwestern periphery of the subtropical ridge and began to slowly change to a more northwesterly course on the 24th some 330 miles east of Leyte.

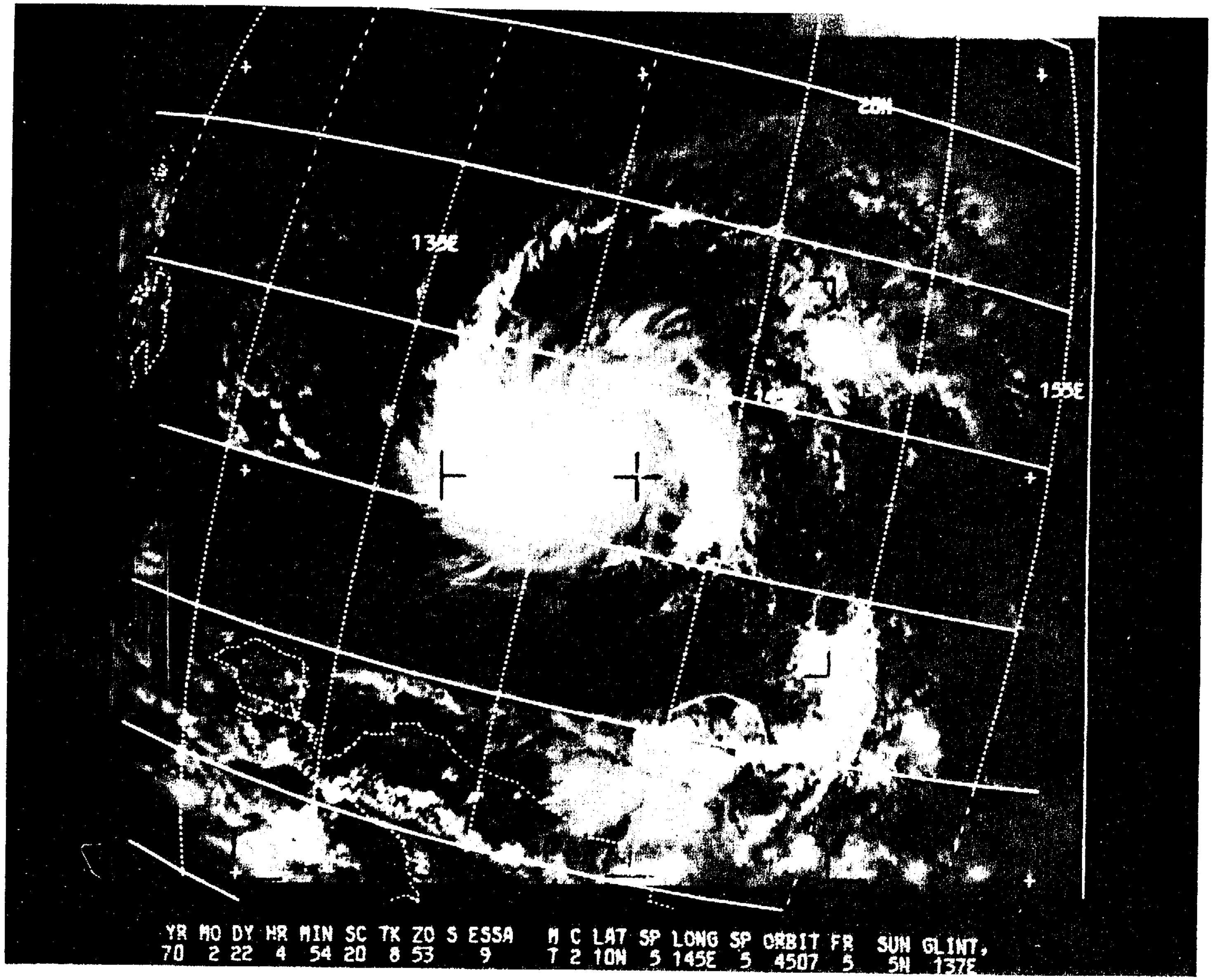


FIGURE 5-1 ESSA 9 VIEW OF NANCY TAKEN ON 22 FEBRUARY SHORTLY AFTER REACHING TYPHOON INTENSITY.

Nancy was near her peak intensity at 120 knots (Figure 5-2) when the American ship Antinous bound from Manila to Guam was caught in her eye shortly before midnight on the 24th about 90 miles east of Samar. The ship's log referred to monstrous confused seas with winds well over 100 knots and wave swell heights over 40 feet. Three large butane tanks on the main deck broke loose and carried away a large portion of the bulwark. A minimum pressure of 953 mb was recorded while in the eye. The barograph track of the Antinous is reproduced in Figure 5-3.

As the typhoon commenced to recurve, her track brought the edge of the eye over Catanduanes Island on the afternoon of the 25th. The U. S. Coast Guard loran station on the island recorded a maximum wind of 120 knots before the wind indicating equipment jammed. A duplicate of the Antinous' minimum pressure of 953 mb was logged by the station's barometer while in the eye.

Paralleling the Luzon coast some 100 miles offshore, Nancy began to slowly weaken as she approached the westerlies. Turning on a northeast course she decreased to tropical storm strength on the 26th. Becoming extratropical she was absorbed into a frontal zone late on the 27th some 240 miles southeast of Okinawa.

Property damage on the Philippine islands of Catanduanes and Samar was estimated near a million dollars (U.S.) with about 5,000 families rendered homeless.

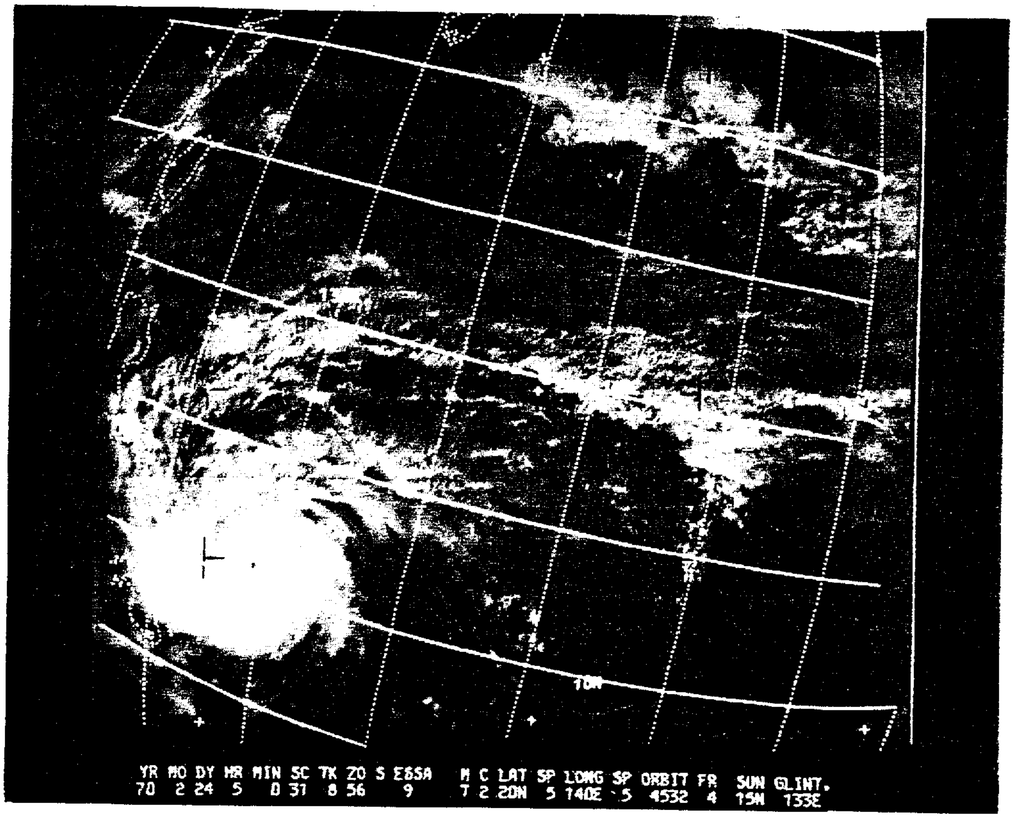


FIGURE 5-2 ESSA 9 PHOTO OF NANCY TAKEN ON 24 FEBRUARY NEAR ITS PEAK STRENGTH 120 KTS

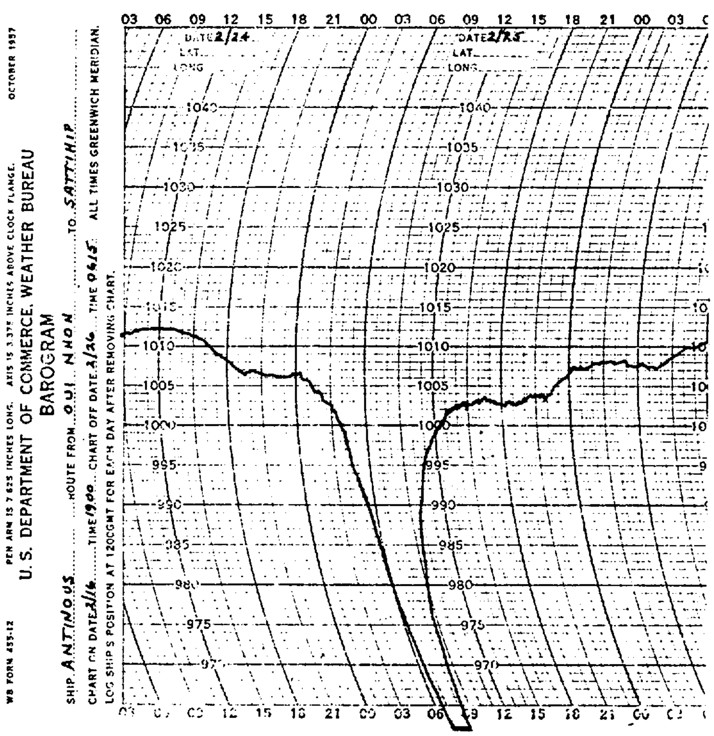


FIGURE 5-3 REPRODUCTION OF BAROGRAPH TRACE FROM THE <u>SS ANTINOUS</u> DURING ENCOUNTER WITH TYPHOON NANCY. TRACE WOULD HAVE BEEN LOWER BUT NEEDLE RESTING ON BASE. SHIP'S BAROMETER REACHED 28.06 IN. (953 MB) WHILE IN NANCY'S EYE.

TYPHOON NANCY

EYE FIXES CYCLONE 01

FIX NO.	TIME	POSIT	UNIT-METHOD-ACCY	FLT LVL	FLT LVL WND	OBS SFC WND	OBS MIN SLP	MIN 700MB HGT	FLT LVL TT/TO	EYE FORM	ORIENTATION	EYE DIA	CHARACTER WALL CLOUD
1	190354Z	09.5N 152.0E	SLTLS	STG B	DIA --	CAT -							----------
2	192300Z	08.6N 149.1E	54-P-02---	700MB	060	055	986	3011	18/--	----			APRNT W/C FORMG
3	200300Z	08.7N 148.6E	54-P-03---	700MB	065	065	986	2996	16/12	----			PARTIAL W/C N SEMICIR
4	200452Z	09.0N 147.5E	SLTLS	STG C	DIA --	CAT -							----------
5	200900Z	08.6N 147.5E	VW-P-03---	0290M	035	035	990	---	26/25	----			NEG W/C
6	201500Z	08.3N 147.4E	VW-P-03---	700MB	050	045	987	3048	26/26	----			W/C SE QUAD-12NM THK
7	202045Z	08.6N 147.1E	54-P-05---	700MB	050	045	992	3027	13/12	----			W/C SW-W-10NM THK
8	210230Z	08.5N 146.0E	54-P-05---	700MB	040	050	989	3005	12/11	----			W/C DISIPTG
9	210356Z	08.0N 145.0E	SLTLS	STG C	DIA --	CAT -							----------
10	210851Z	08.6N 145.1E	VW-P-05---	0290M	---	050	984	---	28/23	----			NEG W/C
11	211445Z	08.4N 144.3E	VW-P-05---	700MB	040	---	---	3008	16/13	----			----------
12	212100Z	08.1N 143.1E	54-P-05---	700MB	047	030	980	2938	16/12	----			10NM THK, BRKN ALQUADS
13	220330Z	08.1N 141.8E	54-P-03---	700MB	046	060	978	2890	15/12	----			10NM THK
14	220454Z	08.5N 141.0E	SLTLS	STG X	DIA 02	CAT 2							----------
15	220830Z	08.2N 140.5E	VW-P-05---	4500M	---	110	972	---	25/24	CIRC	----	44	----------
16	221200Z	08.6N 139.9E	VW-Q-04---	4600M	040	---	---	---	--/--	CIRC	----	42	----------
17	221514Z	08.7N 139.0E	VW-P-05---	2590M	---	125	967	---	27/26	ELIP	NE-SW	40X--	W/C ALQUADS, 10NM THK
18	222045Z	09.1N 137.7E	54-P-05---	700MB	065	---	958	2752	23/12	CIRC	----	25	10NM THK
19	230225Z	09.2N 136.1E	54-P-08---	700MB	085	100	963	2786	22/12	CIRC	----	40	OPEN NE
20	230553Z	09.5N 135.5E	SLTLS	STG X	DIA 03	CAT 4							----------
21	230851Z	09.2N 135.1E	VW-P-05---	2440M	---	120	959	---	26/24	ELIP	N-S	40X--	10NM THK, OPEN N
22	231205Z	09.3N 134.6E	VW-Q-15---		---	---	---	---	--/--	CIRC	----	40	----------
23	231647Z	10.2N 132.7E	VW-P-10---	2380M	---	130	955	---	28/24	ELIP	NW-SE	40X--	50NM THK-NW
24	232100Z	10.1N 131.8E	54-P-10---	700MB	098	---	950	2670	22/11	ELIP	NE-SW	38X30	----------
25	240230Z	10.4N 130.1E	54-P-10---	700MB	100	120	953	2707	22/13	CIRC	----	40	----------
26	240501Z	10.5N 129.5E	SLTLS	STG X	DIA 03	CAT 4							----------
27	240900Z	11.2N 128.6E	VW-P-03---	700MB	---	130	949	2758	26/22	CIRC	----	25	CLSD, 23NM THK
28	241430Z	11.7N 127.0E	VW-P-02---	700MB	---	---	953	2664	19/13	CIRC	----	22	22NM THK
29	242100Z	12.5N 126.2E	54-P-02---	700MB	---	---	---	2606	18/12	CIRC	----	23	7NM THK, OPEN E
30	250300Z	13.5N 125.2E	54-P-10---	500MB	090	---	952	---	05/-7	CIRC	----	30	----------
31	250528Z	13.7N 124.5E	VW-P-03---	700MB	---	---	---	2752	16/14	ELIP	N-S	36X--	CLSD, 15NM THK
32	250559Z	14.0N 124.5E	SLTLS	STG X	DIA 03	CAT 4							----------
33	250925Z	14.3N 124.1E	VW-P-03---	700MB	---	---	953	2682	18/13	CIRC	----	40	14NM THK
34	251445Z	15.0N 123.9E	VW-P-02---	700MB	102	---	970	2679	20/14	CIRC	----	36	12NM THK
35	252100Z	15.8N 123.7E	54-P-02---	500MB	---	---	---	2682	04/52	CIRC	----	62	8NM THK, OPEN SE
36	260215Z	16.8N 123.8E	54-P-05---	700MB	---	080	---	2713	18/12	CIRC	----	20	8NM THK
37	260503Z	17.0N 123.5E	SLTLS	STG X	DIA 03	CAT 4							----------
38	260915Z	18.1N 124.0E	VW-Q-------		---	---	---	---	--/--	CIRC	----	36	OPEN SW-WSW
39	261407Z	19.0N 124.6E	VW-Q-05---		---	---	---	---	--/--	CIRC	----	18	WK W/C
40	262100Z	20.3N 125.1E	54-P-10---	700MB	035	---	992	3015	--/--	----			NEG W/C
41	270000Z	20.5N 125.3E	54-P-02---	700MB	045	---	992	3042	--/--	----			NEG W/C
42	270210Z	20.6N 125.2E	54-P-02---	700MB	038	---	000	3045	--/--	----			----------
43	270912Z	21.5N 126.3E	VW-P-10---	0260M	---	025	001	---	26/23	----			----------

TYPHOON NANCY

TROPICAL CYCLONE 01 -- 2/19/2300Z TO 2/27/1100Z
POSITION AND FORECAST VERIFICATION DATA

WARN NO.	DTG	WARNING POSIT LAT	WARNING POSIT LONG	BEST TRACK LAT	BEST TRACK LONG	24 HR FCST LAT	24 HR FCST LONG	24 HR ERROR DEG DIST	48 HR FCST LAT	48 HR FCST LONG	48 HR ERROR DEG DIST	72 HR FCST LAT	72 HR FCST LONG	72 HR ERROR DEG DIST
01	19/2300Z	8.6N	149.1E	8.6N	149.1E	10.3N	146.2E	346-0102	11.9N	143.3E	008-0228	13.5N	140.3E	035-0312
02	20/0500Z	8.8N	148.4E	8.7N	148.2E	10.6N	145.4E	354-0120	12.3N	142.4E	012-0246	-----	------	--------
03	20/1100Z	8.9N	147.3E	8.4N	147.2E	9.8N	143.8E	325-0090	10.7N	140.4E	005-0138	11.6N	137.0E	051-0204
04	20/1700Z	8.4N	147.2E	8.4N	147.6E	8.7N	144.5E	057-0042	8.8N	141.8E	090-0180	-----	------	--------
05	20/2300Z	8.6N	146.8E	8.6N	146.7E	8.8N	144.8E	071-0126	8.9N	142.8E	093-0330	9.0N	140.8E	097-0564
06	21/0500Z	8.5N	145.7E	8.6N	145.7E	8.5N	142.3E	067-0042	8.5N	139.0E	102-0192	-----	------	--------
07	21/1100Z	8.6N	144.8E	8.5N	144.8E	8.6N	141.0E	076-0048	8.6N	137.0E	106-0168	8.6N	133.0E	119-0324
08	21/1700Z	8.5N	144.0E	8.3N	143.8E	8.5N	140.2E	102-0084	8.5N	136.2E	115-0216	-----	------	--------
09	21/2300Z	8.1N	142.7E	8.1N	142.7E	7.4N	137.5E	173-0108	7.1N	132.3E	162-0192	7.6N	128.0E	158-0336
10	22/0500Z	8.0N	141.5E	8.2N	141.5E	7.3N	136.4E	162-0114	7.1N	131.2E	156-0228	-----	------	--------
11	22/1100Z	8.1N	140.0E	8.4N	140.1E	8.1N	134.1E	180-0078	8.1N	128.4E	176-0192	8.8N	123.7E	184-0342
12	22/1700Z	8.8N	138.5E	8.8N	138.7E	9.0N	133.1E	169-0066	9.0N	127.4E	170-0174	-----	------	--------
13	22/2300Z	9.2N	137.1E	9.2N	137.2E	11.0N	131.3E	008-0048	12.7N	125.9E	134-0006	15.3N	121.8E	244-0120
14	23/0500Z	9.5N	135.4E	9.2N	135.7E	10.9N	129.4E	341-0018	12.6N	124.2E	202-0060	-----	------	--------
15	23/1100Z	9.3N	134.6E	9.4N	134.2E	9.8N	129.8E	134-0126	11.1N	125.5E	159-0216	13.1N	122.0E	202-0336
16	23/1700Z	10.2N	132.4E	10.1N	132.8E	11.7N	127.1E	134-0012	14.2N	122.7E	220-0090	-----	------	--------
17	23/2300Z	10.3N	131.3E	10.2N	131.2E	11.5N	126.4E	158-0078	13.7N	122.6E	202-0156	16.8N	120.0E	234-0360
18	24/0500Z	10.6N	129.5E	10.6N	129.6E	12.2N	123.9E	207-0090	15.3N	120.1E	242-0234	-----	------	--------
19	24/1100Z	11.2N	128.1E	11.3N	128.2E	13.4N	122.9E	226-0090	17.0N	120.1E	252-0246	21.0N	120.5E	--------
20	24/1700Z	11.9N	126.5E	11.9N	126.8E	14.5N	121.7E	246-0126	18.4N	119.9E	258-0282	-----	------	--------
21	24/2300Z	12.6N	125.7E	12.8N	125.8E	15.5N	121.8E	249-0114	19.4N	120.8E	057-0252	23.8N	123.8E	--------
22	25/0500Z	13.7N	124.7E	13.6N	124.7E	17.7N	122.2E	288-0090	21.4N	122.9E	276-0162	-----	------	--------
23	25/1100Z	14.5N	123.9E	14.5N	124.1E	18.4N	122.4E	273-0102	22.0N	124.8E	--------	25.2N	130.2E	--------
24	25/1700Z	15.3N	123.5E	15.4N	123.8E	19.1N	122.7E	262-0114	22.9N	126.0E	--------	-----	------	--------
25	25/2300Z	16.1N	123.4E	16.2N	123.7E	19.3N	123.0E	242-0132	23.0N	126.0E	--------	-----	------	--------
26	26/0500Z	17.2N	123.7E	17.2N	123.8E	20.9N	124.5E	261-0072	24.2N	129.3E	--------	-----	------	--------
27	26/1100Z	18.4N	123.9E	18.3N	124.2E	22.9N	127.1E	--------	26.5N	133.8E	--------	-----	------	--------
28	26/1700Z	19.6N	124.7E	19.4N	124.8E	22.9N	128.9E	--------	26.3N	135.5E	--------	-----	------	--------
29	26/2300Z	20.6N	125.4E	20.4N	125.2E	23.9N	129.9E	--------	26.7N	137.2E	--------	-----	------	--------
30	27/0500Z	20.8N	125.4E	21.1N	125.8E	-----	------	--------	-----	------	--------	-----	------	--------
31	27/1100Z	21.7N	126.5E	-----	------	-----	------	--------	-----	------	--------	-----	------	--------

AVERAGE 24 HOUR ERROR - 0085 MI. 95.8
AVERAGE 48 HOUR ERROR - 0190 MI.
AVERAGE 72 HOUR ERROR - 0322 MI.

B. TYPHOON OLGA 28 JUN 2300Z-05 JUL 2300Z

1. STATISTICS

   a. Number of Warnings Issued - 29

   b. Number of Warnings with Typhoon Intensity - 22

   c. Distance Traveled During Warning Period - 2,382 MI

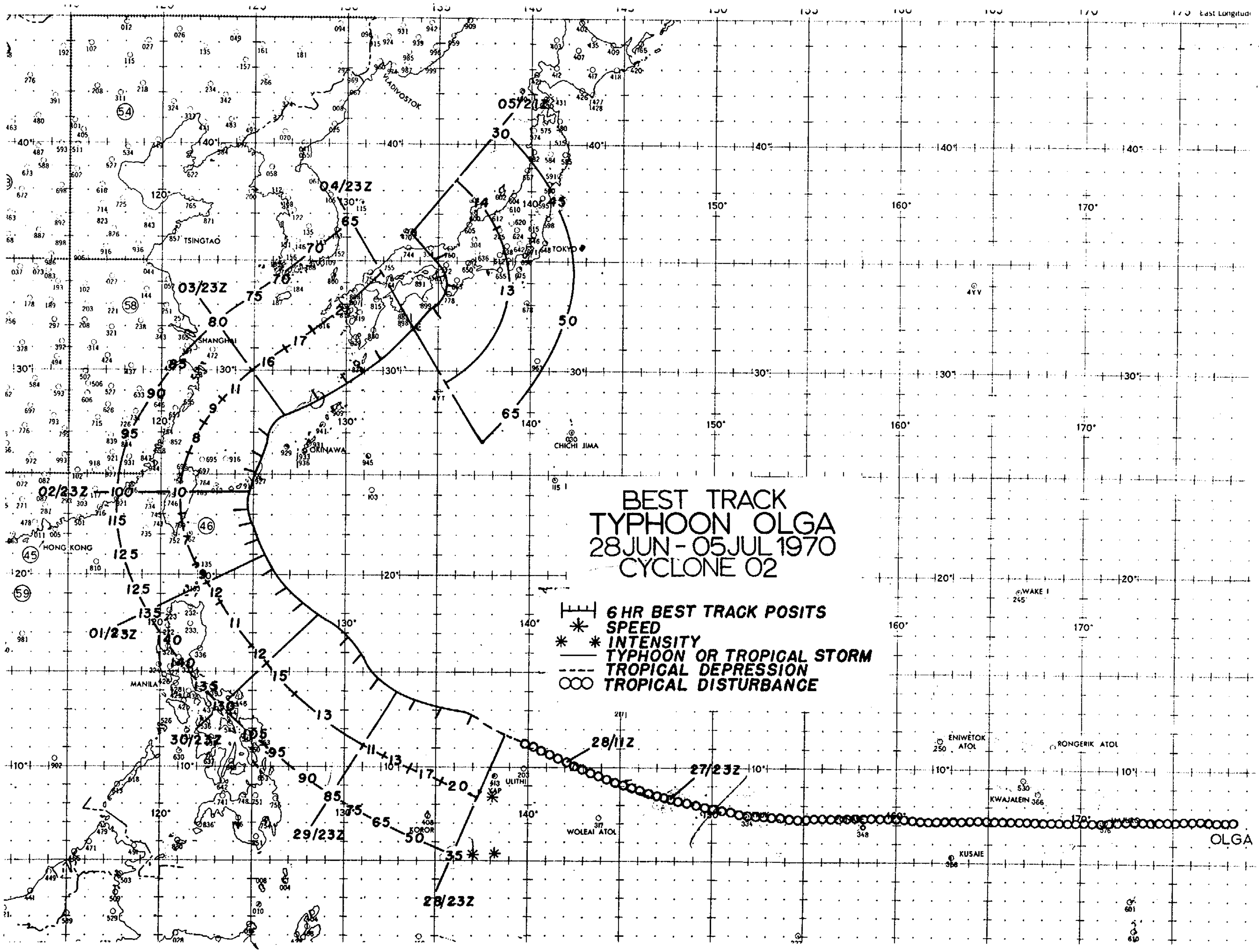
2. CHARACTERISTICS AS A TYPHOON

   a. Minimum Observed SLP - 904 MBS at 01/2118Z

   b. Minimum Observed 700 MB Height - 2268 M at 01/2100Z

   c. Maximum Surface Wind - 140 KTS (From Best Track)

   d. Maximum Radius of Surface Circulation - 360 MI


BEST TRACK
TYPHOON OLGA
28JUN - 05JUL 1970
CYCLONE 02
6 HR BEST TRACK POSITS
SPEED
INTENSITY
TYPHOON OR TROPICAL STORM
TROPICAL DEPRESSION
TROPICAL DISTURBANCE
East Longitude
04/23Z
03/23Z
02/23Z
01/23Z
30/23Z
29/23Z
28/23Z
28/11Z
27/23Z
OLGA
VLADIVOSTOK
TSINGTAO
SHANGHAI
OKINAWA
TOKYO
CHICHI JIMA
HONG KONG
MANILA
ULITHI
YAP
KOROR
WOLEAI ATOL
WAKE I
ENIWETOK ATOL
RONGERIK ATOL
KWAJALEIN
KUSAIE

3. TYPHOON OLGA NARRATIVE

After a four month lull of tropical cyclone activity, the subtropical ridge began to build in mid-June producing a broad flow of easterlies in the tropics south of 25°N and increasing tropical wave frequency.

The pre-Olga system was first noted by a wave passage at Majuro in the Marshall Island group on the 24th. Signs of a developing disturbance were detected as satellite pictures from ESSA-8 and ITOS-1 on the 26th showed considerable convective activity and evidence of banding as the wave reached the Truk-Ponape vicinity in the Central Carolines.

A tight pressure gradient existed south of the ridge line causing strong easterlies and a westward movement of the pre-Olga system in excess of 20 knots. This rate of forward speed apparently inhibited the establishment of a circulation at the surface until the system was southwest of Guam early on the 29th. Reconnaissance detected a closed center at first light just north of Ulithi Island with maximum winds of 35-40 knots (Figure 5-4).

The newly-developed storm assumed a northwest course upon entrance into the Philippine Sea as weakening occurred along the subtropical ridge line in the vicinity of the Ryukyu Islands. On this track, Olga was in a favorable region for further intensification as she approached difluent flow aloft associated with a 200 mb anticyclone south of the Ryukyu chain. The forward speed of the storm decreased to 13 knots and Olga reached typhoon strength by evening on the 29th and within 36 hours became the season's first super typhoon.

Deepening had occurred at a rapid rate during this period culminating in a 904 mb central pressure on July 1st when Olga was 300 miles due east of the northeastern tip of Luzon. This reduction of pressure represented an explosive deepening of 62 mb in 24 hours. Winds generated under the wall cloud region, surrounding a tight 6 mile diameter eye, were estimated near 140 knots at this point (Figure 5-5). The building of heights and establishment of a high cell in the vicinity of Iwo Jima created a relative weakness in the ridge line near the 125th meridian while Olga was reaching her maximum intensity. The storm reacted to this opened avenue by gradually shifting course northward on the 1st.

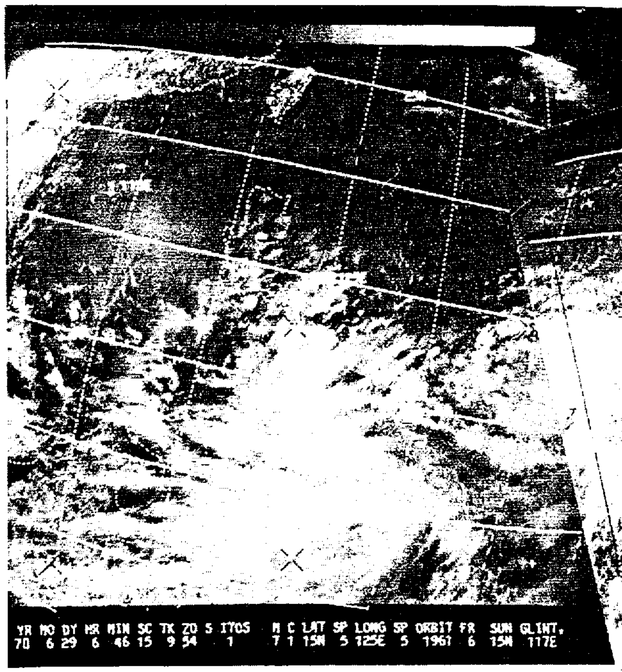
A short wave in the westerlies was nearing the Asian coast as the typhoon passed between Taiwan and Okinawa the following day. In response to the approach of the short wave, the typhoon took a sharp turn to the northeast while passing 100 miles abeam of Okinawa, and began to accelerate in forward

speed reaching 21 knots south of Kyushu some 12 hours later. A developing low in the short wave system moving into the Sea of Japan brought its influence on the scene by slowing and deflecting the storm's course to the northwest. The weakening Olga arrived ashore on Honshu's Kii Peninsula south of Osaka on the 5th with winds of tropical storm force.

Highest winds reported during the typhoon's transit through and west of the Ryukyu's occurred at Kume Shima which recorded 90 knots gusting to 110 knots during the early morning hours of the 4th some 50 miles east of the center.

Olga had weakened in strength considerably just before reaching the Ryukyu's early on the 3rd as dry air began to enter the system. The vertical extent of convective activity associated with the storm was markedly shallow during the period it traversed the East China Sea as reconnaissance aircraft were topping the typhoon's cloudiness at 10,000 feet.

Upon crossing Honshu and entering the Sea of Japan, Olga merged with a cold low. Heavy rains attended the system while crossing Japan and later as it drifted over South Korea. The excessive rains (up to 13 inches in Japan) caused landslides and extensive flooding in some areas which was responsible for at least 8 deaths in Japan and 29 deaths in South Korea. Damage was estimated near 10 million dollars in and around Tokyo.



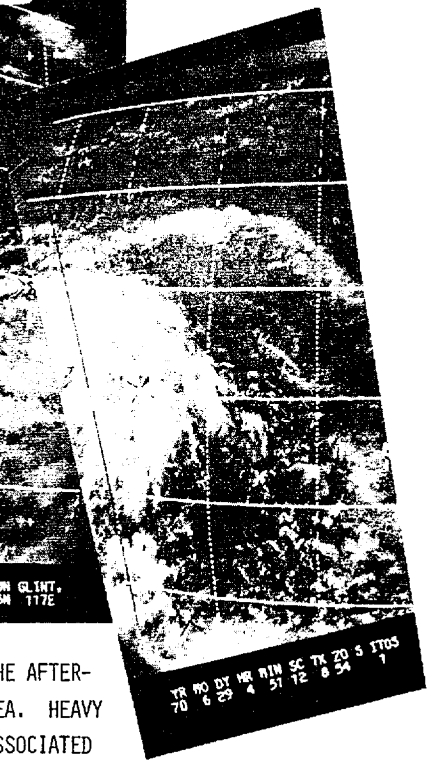


FIGURE 5-4 ITOS-1 VIEW OF OLGA NEAR TYPHOON INTENSITY THE AFTERNOON OF 29 JUNE IN THE SOUTHERN PHILIPPINE SEA. HEAVY CONVECTIVE ACTIVITY TO THE WEST OF OLGA IS ASSOCIATED WITH TROPICAL STORM PAMELA A SHORT DISTANCE EAST OF MINDANAO.

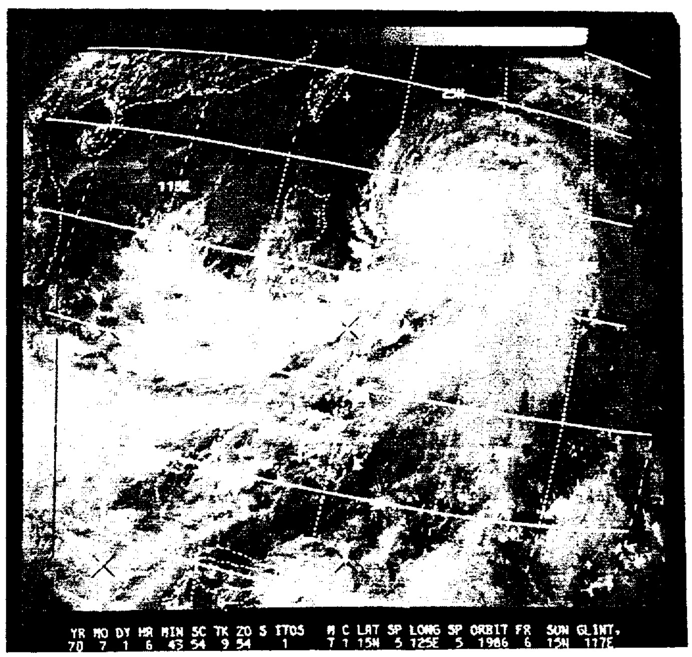


FIGURE 5-5 OLGA ON 1 JULY, OF SUPER TYPHOON INTENSITY LOCATED EAST OF NORTHERN LUZON AS SEEN BY CAMERA'S ABOARD ITOS-1.

TYPHOON OLGA

EYE FIXES CYCLONE [illegible]2

FIX NO.	TIME	POSIT	UNIT-METHOD-ACCY	FLT LVL	FLT LVL WND	OBS SFC WND	OBS MIN SLP	MIN 700MB HGT	FLT LVL TT/TO	EYE FORM	ORIEN-TATION	EYE DIA	CHARACTER WALL CLOUD
1	280550Z	10.0N 145.[illegible]E	SLTLS	STG B	DIA --		CAT -						----------
2	290225Z	12.5N 137.6E	54-P-07---	0420M	045	040	993	---	25/23	CIRC	----	18	W/C FORMG, OPEN SW
3	290646Z	13.0N 137.0E	SLTLS	STG X	DIA 02		CAT 2						----------
4	290646Z	13.0N 137.0E	SLTLS	STG X	DIA 02		CAT 2						----------
5	290945Z	13.0N 135.6E	VW-P-10---	0400M	---	050	---	---	--/27	CIRC	----	08	----------
6	291457Z	13.4N 134.3E	VW-P-10---	0200M	040	---	---	---	--/--	ELIP	NE-SW	16x13	W/C N QUAD, 18NM THK
7	292040Z	13.7N 133.3E	54-P-15---	700MB	060	100	966	2783	17/11	CIRC	----	12	10NM THK, OPEN NW QUAD
8	300200Z	14.3N 132.4E	54-P-15---	700MB	080	110	964	2768	21/11	CIRC	----	12	W/C E QUAD, 8NM THK
9	300548Z	14.5N 131.0E	SLTLS	STG X	DIA 03		CAT 2						----------
10	300929Z	15.5N 131.2E	VW-P-02---		---	---	---	---	24/21	----			CLSD
11	301211Z	16.0N 130.9E	VW-P-03---	700MB	070	045	978	2911	16/09	CIRC	----	12	10NM THK, OPEN NW
12	302100Z	17.5N 129.1E	54-P-03---	700MB	075	110	929	2481	18/10	CIRC	----	08	CLSD, 10NM THK
13	010000Z	17.9N 128.3E	54-P-03---	700MB	100	150	908	2301	24/11	CIRC	----	07	CLSD, 5NM THK
14	010218Z	18.2N 128.0E	54-P-03---	700MB	120	110	904	2268	24/12	CIRC	----	06	CLSD, 7NM THK
15	010644Z	19.0N 127.5E	SLTLS	STG X	DIA 04		CAT 4						CLSD
16	010909Z	19.0N 127.3E	VW-P-03---	0300M	---	---	---	---	--/--	CIRC	----	10	CLSD, 4NM THK
17	011502Z	20.2N 126.5E	VW-P-03---	0400M	---	---	---	---	--/--	CIRC	----	07	CLSD, 4NM THK
18	012000Z	20.4N 125.7E	54-P-02---	700MB	090	---	920	2320	18/10	CIRC	----	04	CLSD
19	020015Z	21.0N 125.6E	54-P-02---	700MB	090	130	915	2340	25/13	CIRC	----	06	CLSD
20	020300Z	21.4N 125.4E	54-P-02---	700MB	060	130	920	2380	19/15	CIRC	----	15	CLSD
21	020550Z	21.2N 124.9E	SLTLS	STG X	DIA 05		CAT 4						----------
22	020600Z	21.9N 125.2E	LND RDR		---	---	---	---	--/--	----			----------
23	020700Z	22.0N 125.1E	LND RDR		---	---	---	---	--/--	----			----------
24	020800Z	22.1N 125.0E	LND RDR		---	---	---	---	--/--	----			----------
25	020855Z	22.5N 125.1E	VW-P-25---	0080M	002	---	---	---	--/--	CIRC	----	09	CLSD
26	020900Z	22.1N 125.0E	LND RDR		---	---	---	---	--/--	----			----------
27	020900Z	22.2N 125.0E	LND RDR		---	---	---	---	--/--	----			----------
28	021000Z	22.2N 125.0E	LND RDR		---	---	---	---	--/--	----			----------
29	021100Z	22.4N 125.0E	LND RDR		---	---	---	---	--/--	----			----------
30	021200Z	22.3N 125.0E	LND RDR		---	---	---	---	--/--	----			----------
31	021300Z	22.5N 125.0E	LND RDR		---	---	---	---	--/--	----			----------
32	021400Z	22.8N 125.0E	LND RDR		---	---	---	---	--/--	----			----------
33	021500Z	23.0N 125.0E	LND RDR		---	---	---	---	--/--	----			----------
34	021515Z	22.9N 124.7E	VW-P-05---		070	080	---	---	--/--	CIRC	----	08	14NM THK, OPEN W
35	021600Z	23.0N 125.0E	LND RDR		---	---	---	---	--/--	----			----------
36	021710Z	23.2N 125.0E	LND RDR		---	---	---	---	--/--	----			----------
37	021800Z	23.3N 124.8E	LND RDR		---	---	---	---	--/--	----			----------
38	021900Z	23.6N 124.9E	LND RDR		---	---	---	---	--/--	----			----------
39	022000Z	23.6N 124.9E	LND RDR		---	---	---	---	--/--	----			----------
40	022045Z	23.6N 124.9E	54-P-08---	700MB	075	075	950	2640	18/12	----			W/C E QUAD
41	022100Z	23.9N 125.1E	LND RDR		---	---	---	---	--/--	----			----------
42	030100Z	24.5N 124.9E	LND RDR		---	---	---	---	--/--	----			----------
43	030230Z	24.8N 125.0E	54-P-02---	700MB	070	125	960	2728	17/14	----			W/C SE QUAD
44	030300Z	24.8N 125.0E	LND RDR		---	---	---	---	--/--	----			----------
45	030646Z	24.0N 125.1E	SLTLS	STG X	DIA 0		CAT 3						----------
46	030700Z	25.2N 125.3E	LND RDR		---	---	---	---	--/--	----			----------
47	030830Z	25.8N 125.7E	LND RDR		---	---	---	---	--/--	----			----------
48	030900Z	25.3N 125.5E	VW-P-03---	700MB	---	---	---	---	--/--	CIRC	----	11	----------

124 54

TYPHOON OLGA
EYE FIXES CYCLONE 02

FIX NO.	TIME	POSIT	UNIT-METHOD-ACCY	FLT LVL	FLT LVL WND	OBS SFC WND	OBS MIN SLP	MIN 700MB HGT	FLT LVL TT/TO	EYE FORM	ORIEN-TATION	EYE DIA	CHARACTER WALL CLOUD
49	031030Z	25.7N 125.6E	LND RDR		---	---	---	---	--/--	----			----------
50	031049Z	25.8N 125.5E	VW-P-03---	700MB	---	---	963	2777	22/13	CIRC	----	05	CLSD
51	031110Z	25.7N 125.2E	LND RDR		---	---	---	---	--/--	----			----------
52	031230Z	25.7N 125.7E	LND RDR		---	---	---	---	--/--	----			----------
53	031430Z	26.0N 125.9E	LND RDR		---	---	---	---	--/--	----			----------
54	031508Z	26.4N 125.7E	VW-P-02---	700MB	---	---	---	2835	25/14	CIRC	----	12	CLSD
55	031630Z	25.8N 126.6E	LND RDR		---	---	---	---	--/--	----			----------
56	032055Z	27.3N 126.0E	54-P-05---	700MB	065	065	948	3088	21/12	CIRC	----	20	WK W/C SE QUAD
57	040200Z	27.9N 127.8E	54-P-05---	700MB	060	050	955	2725	22/14	CIRC	----	--	APRNT WK W/C SE-W
58	040547Z	28.0N 128.0E	SLTLS	STG X	DIA 03	CAT 2							----------
59	040922Z	29.0N 129.5E	VW-P-05---	700MB	004	075	---	2826	21/14	----			OPEN N
60	041300Z	29.7N 130.9E	VW-P------		---	---	---	2896	--/--	----			----------
61	041430Z	29.9N 131.1E	VW-P-05---	700MB	080	---	967	2810	21/15	----			DIFF TO LOCATE EYE ON RDR
62	041800Z	30.9N 132.4E	LND RDR		---	---	---	---	--/--	----			----------
63	041900Z	30.9N 132.7E	LND RDR		---	---	---	---	--/--	----			----------
64	042000Z	31.3N 133.2E	LND RDR		---	---	---	---	--/--	----			----------
65	042100Z	31.4N 133.4E	LND RDR		---	---	---	---	--/--	----			----------
66	042104Z	31.6N 133.3E	54-P-05---	700MB	065	075	959	2740	17/14	ELIP	N-S	30X20	10NM THK, OPEN N
67	042200Z	31.6N 133.4E	LND RDR		---	---	---	---	--/--	----			----------
68	042300Z	31.7N 133.7E	LND RDR		---	---	---	---	--/--	----			----------
69	050235Z	32.3N 134.3E	54-P-05---		047	065	953	---	16/14	ELIP	N-S	45X30	6NM THK, OPEN NE
70	050449Z	32.0N 135.1E	SLTLS	STG X	DIA 03	CAT 3							----------
71	050750Z	33.3N 135.1E	VW-P-03---		---	---	---	---	--/--	----			----------
72	050800Z	33.2N 135.3E	LND RDR		---	---	---	---	--/--	----			----------
73	050900Z	33.2N 135.5E	LND RDR		---	---	---	---	--/--	----			----------
74	050906Z	33.4N 135.6E	VW-P-03---		---	---	---	---	--/--	CIRC	----	10	3NM THK, OPEN S&W QUAD
75	051200Z	34.2N 135.4E	LND RDR		---	---	---	---	--/--	----			----------
76	051300Z	34.3N 135.2E	LND RDR		---	---	---	---	--/--	----			----------
77	051400Z	34.4N 135.3E	LND RDR		---	---	---	---	--/--	----			----------
78	051600Z	34.8N 134.8E	LND RDR		---	---	---	---	--/--	----			----------
79	051700Z	35.0N 134.8E	LND RDR		---	---	---	---	--/--	----			----------
80	051800Z	35.6N 134.5E	LND RDR		---	---	---	---	--/--	----			----------
81	051900Z	35.9N 134.1E	LND RDR		---	---	---	---	--/--	----			----------
82	052000Z	35.9N 133.9E	LND RDR		---	---	---	---	--/--	----			----------
83	052100Z	36.1N 133.7E	LND RDR		---	---	---	---	--/--	----			----------

TYPHOON OLGA

TROPICAL CYCLONE 02 -- 6/28/2300Z TO 7/5/2300Z
POSITION AND FORECAST VERIFICATION DATA

WARN NO.	DTG	WARNING POSIT LAT	WARNING POSIT LONG	BEST TRACK LAT	BEST TRACK LONG	24 HR FCST LAT	24 HR FCST LONG	24 HR ERROR DEG DIST	48 HR FCST LAT	48 HR FCST LONG	48 HR ERROR DEG DIST	72 HR FCST LAT	72 HR FCST LONG	72 HR ERROR DEG DIST
01	28/2300Z	11.5N	139.3E	11.7N	139.1E	14.0N	132.6E	270-0012	-----	------	--------	-----	------	--------
02	29/0500Z	12.9N	136.9E	12.7N	137.0E	15.7N	129.2E	089-0156	18.3N	122.5E	268-0294	-----	------	
03	29/1100Z	13.1N	135.3E	13.1N	135.3E	15.0N	129.0E	249-0126	17.5N	123.7E	239-0204	20.3N	119.2E	247-0348
04	29/1700Z	13.7N	133.7E	13.5N	133.9E	15.7N	127.3E	248-0174	18.3N	122.0E	245-0252	-----	------	--------
05	29/2300Z	13.9N	132.9E	14.0N	132.9E	15.5N	127.6E	209-0150	17.8N	123.2E	217-0228	20.8N	119.2E	238-0372
06	30/0500Z	14.3N	131.9E	14.8N	131.8E	15.9N	127.2E	189-0156	17.8N	123.0E	208-0270	-----	------	--------
07	30/1100Z	15.8N	131.0E	15.8N	131.1E	18.7N	127.1E	161-0036	20.5N	122.9E	224-0174	22.7N	118.9E	242-0414
08	30/1700Z	16.9N	130.3E	16.8N	130.2E	19.1N	126.0E	180-0060	21.0N	121.9E	230-0210	-----	------	--------
09	30/2300Z	18.0N	128.8E	17.7N	128.9E	21.7N	125.1E	327-0054	25.9N	125.3E	007-0102	30.2N	133.0E	066-0342
10	01/0500Z	18.5N	127.5E	18.5N	127.7E	22.2N	124.5E	299-0048	26.9N	126.4E	280-0114	-----	------	--------
11	01/1100Z	19.2N	126.9E	19.3N	126.8E	22.8N	122.5E	360-0012	26.7N	126.3E	041-0054	30.7N	134.1E	069-0210
12	01/1700Z	20.6N	126.2E	20.1N	126.1E	24.8N	125.5E	019-0090	28.7N	129.6E	061-0216	-----	------	--------
13	01/2300Z	20.9N	125.7E	20.9N	125.7E	24.7N	125.2E	022-0030	28.4N	128.9E	070-0102	31.5N	137.1E	098-0156
14	02/0500Z	21.7N	125.3E	21.8N	125.3E	25.2N	125.5E	090-0012	29.7N	130.5E	052-0114	-----	------	--------
15	02/1100Z	22.7N	125.0E	22.6N	125.1E	26.3N	126.3E	064-0036	30.6N	132.2E	054-0120	35.2N	142.5E	077-0342
16	02/1700Z	23.1N	124.9E	23.3N	124.9E	26.3N	126.3E	161-0036	30.6N	132.2E	090-0006	-----	------	--------
17	02/2300Z	24.1N	125.0E	24.2N	125.0E	27.6N	127.7E	108-0036	31.5N	134.1E	165-0024	36.2N	143.8E	--------
18	03/0500Z	25.1N	125.1E	25.2N	125.3E	28.8N	128.0E	296-0036	32.4N	133.5E	252-0072	-----	------	--------
19	03/1100Z	25.9N	125.5E	26.0N	125.6E	29.8N	128.8E	287-0078	35.0N	134.4E	317-0084	-----	------	--------
20	03/1700Z	26.7N	126.0E	26.9N	126.0E	30.3N	129.1E	264-0150	35.5N	134.8E	326-0018	-----	------	--------
21	03/2300Z	27.6N	126.2E	27.8N	127.0E	31.0N	128.4E	260-0282	34.8N	132.2E	--------	-----	------	--------
22	04/0500Z	28.5N	128.7E	28.5N	128.7E	33.7N	135.0E	000-0054	39.3N	144.2E	--------	-----	------	--------
23	04/1100Z	29.5N	130.2E	29.4N	130.3E	34.4N	137.4E	071-0084	37.0N	150.0E	--------	-----	------	--------
24	04/1700Z	30.3N	131.8E	30.6N	132.1E	34.5N	139.6E	100-0222	35.6N	150.3E	--------	-----	------	--------
25	04/2300Z	31.9N	134.0E	31.9N	134.0E	35.5N	142.8E	--------	-----	------	--------	-----	------	--------
26	05/0500Z	32.7N	135.0E	32.8N	135.0E	35.7N	142.1E	--------	-----	------	--------	-----	------	--------
27	05/1100Z	33.9N	135.5E	33.9N	135.7E	-----	------	--------	-----	------	--------	-----	------	--------
28	05/1700Z	35.0N	135.4E	35.2N	135.1E	-----	------	--------	-----	------	--------	-----	------	--------
29	05/2300Z	36.5N	133.1E	-----	------	-----	------	--------	-----	------	--------	-----	------	--------

AVERAGE 24 HOUR ERROR - 0088 MI.
AVERAGE 48 HOUR ERROR - 0139 MI.
AVERAGE 72 HOUR ERROR - 0312 MI.

C. TYPHOON WILDA 09 AUG 0500Z-15 AUG 1700Z

1. STATISTICS

   a. Number of Warnings Issued - 27

   b. Number of Warnings with Typhoon Intensity - 19

   c. Distance Traveled During Warning Period - 1,860 MI

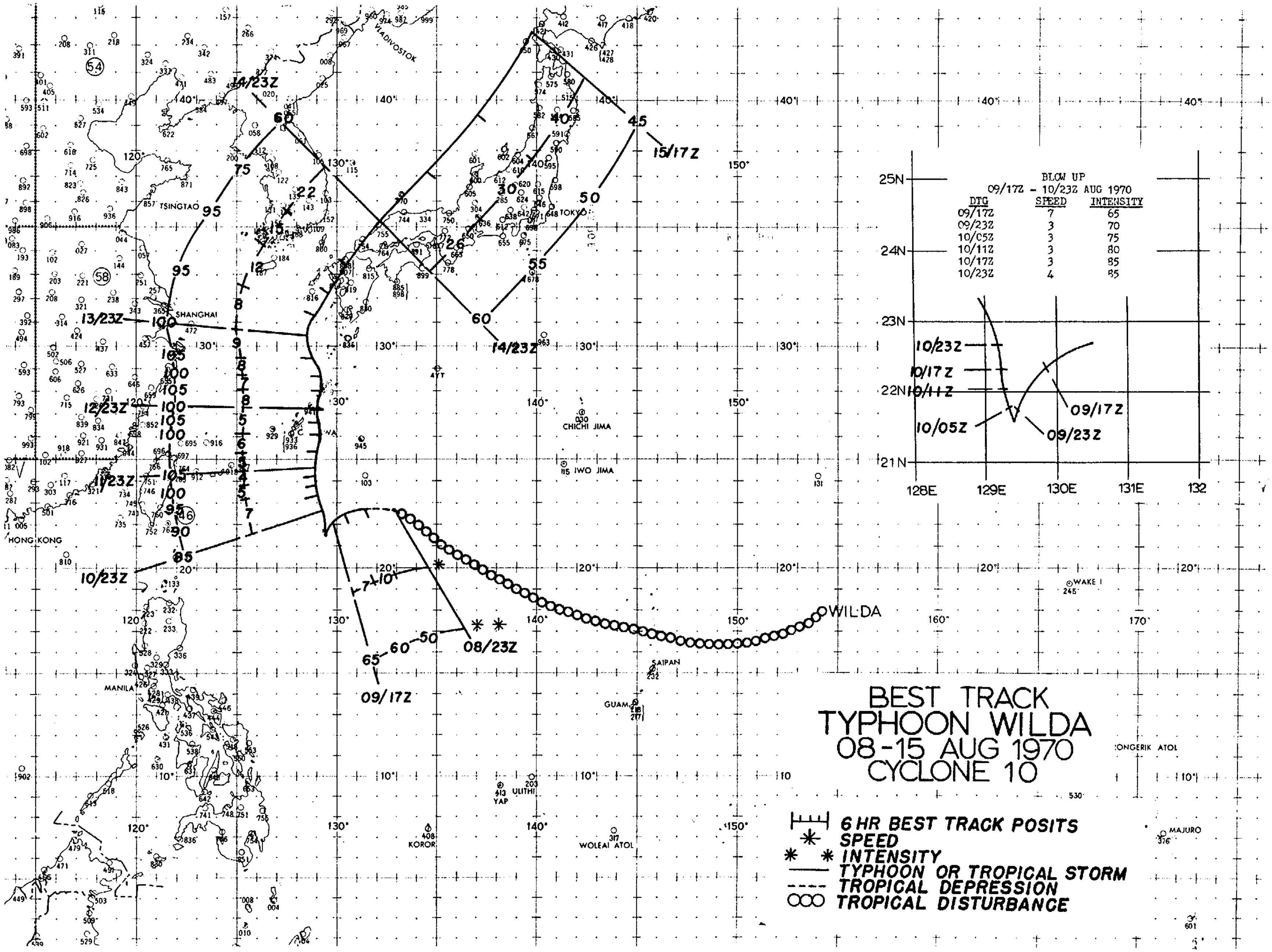
2. CHARACTERISTICS AS A TYPHOON

   a. Minimum Observed SLP - 939 MBS at 11/2100Z

   b. Minimum Observed 700 MB Height - 2585 M at 11/2100Z

   c. Maximum Surface Wind - 105 KTS (From Best Track)

   d. Maximum Radius of Surface Circulation - 540 MI


BEST TRACK
TYPHOON WILDA
08-15 AUG 1970
CYCLONE 10
6 HR BEST TRACK POSITS
SPEED
INTENSITY
TYPHOON OR TROPICAL STORM
TROPICAL DEPRESSION
TROPICAL DISTURBANCE
BLOW UP
09/17Z - 10/23Z AUG 1970
DTG SPEED INTENSITY
09/17Z 7 65
09/23Z 3 70
10/05Z 3 75
10/11Z 3 80
10/17Z 3 85
10/23Z 4 85
WILDA
08/23Z
09/17Z
10/23Z
11/23Z
12/23Z
13/23Z
14/23Z
15/17Z
SHANGHAI
TSINGTAO
HONG KONG
MANILA
TOKYO
VLADIVOSTOK
CHICHI JIMA
IWO JIMA
SAIPAN
GUAM
YAP
ULITHI
KOROR
WOLEAI ATOL
WAKE I
MAJURO

3. TYPHOON WILDA NARRATIVE

Wilda developed from a complex system that had its origin in the region south of Marcus Island. The ITOS-1 satellite pass on the 2nd of August indicated considerable convective activity was occurring in an area between Eniwetok and Marcus Island. This was related to a developing circulation in the upper tropospheric Mid-Pacific trough which had been initially evidenced in upper air data the day before.

An induced surface trough from this system drifted west and developed into a broad circulation as it passed through the Northern Marianas chain on the 6th. The presence of a 200 mb shear line to its north prevented any mechanism for sufficient outflow from the area and stifled further development. As the system corssed into the Philippine Sea a complex situation was created as no increase in net mass inflow into the circulation was noted. The depression expanded and covered some 300 miles in radius with two to three smaller surface circulations embedded as evidenced by ship data and satellite pictures. (Figure 5-6)

By the 9th the large circulation approached a more favorable environment as it neared an area of weak anticyclonic shear at 200 mb and less tropospheric vertical wind shear. ESSA-8 displayed a horseshoe cloud band oriented toward the north surrounding most of the depression and open to the south, with maximum convective activity located in the northwest quadrant. It was from this northwest portion that Wilda rapidly developed. A reconnaissance aircraft on an investigative mission in the vicinity detected a partially developed wall cloud with a central pressure of 986 mb.

Steering forces were weak at this point and the newly formed Wilda began a southwestward drift from a position 300 miles southeast of Okinawa. This movement was largely in response to the influence of the circulation around the massive low from which she developed.

During this time frame a mid-tropospheric high cell over the northern East China Sea began to retrograde leaving a weak trough area to the north of Wilda. As the high continued to recede, the typhoon began to drift northward under its own internal forces (Cressman, 1952) at 4 to 6 knots and intensify. The generally weak gradient between the split ridge line favored a slow northward movement for 3 days.

On this track the storm passed 35 miles east of Okinawa during the night of the 12th to the 13th bringing gale force winds to the island. Naha experienced 52 knots gusting to 64 knots with lowest barometer reading at 978 mb. The eye later passed over the western edge of Amami-o-Shima the following

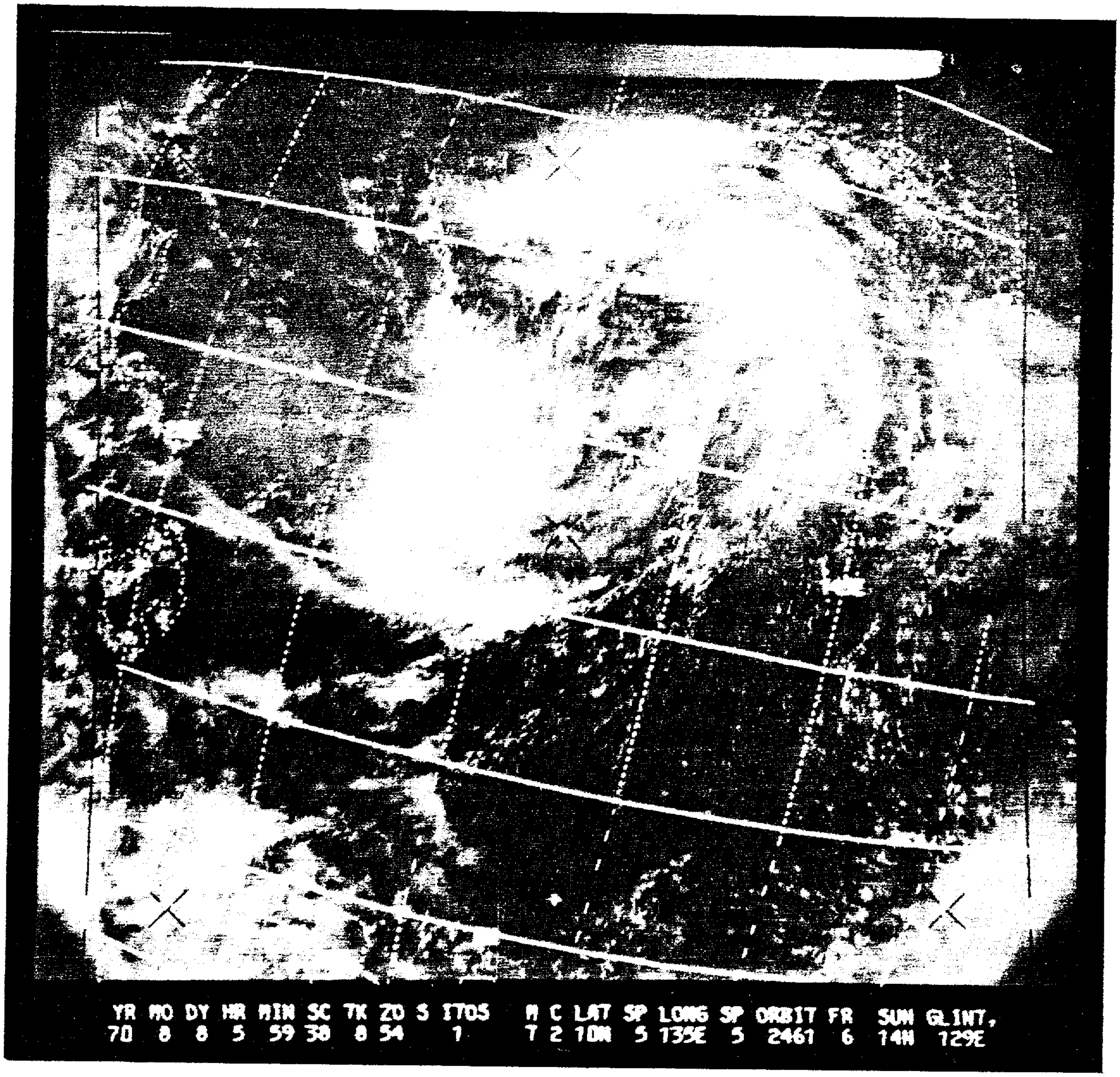


FIGURE 5-6 THE CLOUDINESS ASSOCIATED WITH THE LARGE PRE-WILDA DEPRESSION ON 8 AUGUST APPEARS AS A DISORGANIZED PATTERN TO THE ITOS-1 SATELLITE.

evening with a minimum pressure of 955.8 mb recorded at the island weather station.

In advance of an approaching trough in the westerlies moving off Manchuria, Wilda shifted to a northeast track on the afternoon of the 14th and gradually began to increase in forward speed. This course took the storm with 95 knot winds near the center over Western Kyushu near Nagasaki later that evening (Figure 5-7).

The typhoon was downgraded to a tropical storm as it entered the Sea of Japan with a rate of movement of 22 knots. Wilda started to quickly lose her tropical characteristics as she paralleled the western coast of Honshu some 120 miles offshore. After transforming to extratropical characteristics and skirting western Hokkaido on the 16th the system continued as a well-developed low after passage of the Kamchatka Peninsula on the 17th.

During its lifetime the typhoon reached its maximum strength of 105 knots while east of Okinawa and maintained itself near the 100 knot level until its landfall on the Japanese Coast. Damage reports placed at least 11 persons killed and 326 injured in Japan as the storm brought heavy rain (up to 18 inches) and strong winds to the southern portions of Japan. Over 2,800 houses were reported partially or totally destroyed and 97 vessels of various size sunk or washed away.

FIGURE 5-7 TYPHOON WILDA SOUTHWEST OF KYUSHU ON 14 AUGUST AS VIEWED BY ITOS-1 IN THE AFTERNOON (TOP) AND NIMBUS IV INFRA-RED (ORBIT 1716) THAT NIGHT (BOTTOM).

TYPHOON WILDA

EYE FIXES CYCLONE 10

FIX NO.	TIME	POSIT	UNIT-METHOD-ACCY	FLT LVL	FLT LVL WND	OBS SFC WND	OBS MIN SLP	MIN 700MB HGT	FLT LVL TT/TO	EYE FORM	ORIEN-TATION	EYE DIA	CHARACTER WALL CLOUD
1	090656Z	23.0N 130.5E	SLTLS	STG X	DIA 02	CAT 2							----------
2	090700Z	22.8N 131.1E	VW-P-05---	0450M	---	040	986	---	27/23	ELIP	NW-SE	20X15	HLF MOON NNE TO S, 4NM THK
3	090932Z	22.5N 130.7E	VW-P-05---	700MB	---	045	983	2937	28/24	CIRC	----	13	4NM THK, OPEN S-SE
4	091107Z	22.6N 130.3E	VW-P------		---	---	---	---	--/--	----			----------
5	100020Z	21.7N 129.3E	54-P-03---	700MB	070	080	973	2893	20/16	CIRC	----	15	OPEN SE
6	100250Z	21.7N 129.3E	54-P-03---	700MB	070	110	974	2890	21/11	CIRC	----	10	W/C NW-SE
7	100602Z	21.0N 129.0E	SLTLS	STG X	DIA 03	CAT 2							----------
8	100903Z	21.9N 129.3E	VW-P-05---		---	---	---	---	--/--	----			----------
9	100910Z	22.0N 129.5E	VW-P-08---		---	065	972	---	27/26	CIRC	----	25	5NM THK, OPEN NE QUAD
10	101430Z	22.1N 129.3E	VW-P-05---	700MB	---	065	974	2810	27/23	CIRC	----	08	8NM THK, OPEN NNE
11	102100Z	22.5N 129.1E	54-P-05---	700MB	060	080	970	2795	17/12	CIRC	----	25	OPEN N-NE
12	110300Z	23.1N 129.1E	54-P-03---	700MB	070	090	964	2800	21/13	CIRC	----	20	W/C N QUAD/CLOSING/WK
13	110400Z	23.5N 128.9E	LND RDR		---	---	---	---	--/--	----			----------
14	110658Z	23.0N 128.0E	SLTLS	STG X	DIA 03	CAT 3							----------
15	110853Z	23.5N 129.1E	VW-P-05---		---	---	---	---	--/--	----			OPEN N QUAD
16	110904Z	23.4N 129.0E	VW-P-05---		---	085	957	---	27/25	----			OPEN NW QUAD
17	111210Z	24.0N 129.4E	LND RDR		---	---	---	---	--/--	----			----------
18	111402Z	24.1N 129.0E	LND RDR		---	---	---	---	--/--	----			----------
19	111420Z	24.3N 128.7E	VW-P-03---		---	100	953	2679	27/24	CIRC	----	23	15NM THK, OPEN NW QUAD
20	111500Z	24.2N 128.9E	LND RDR		---	---	---	---	--/--	----			----------
21	111600Z	24.2N 128.8E	LND RDR		---	---	---	---	--/--	----			----------
22	111700Z	24.3N 128.8E	LND RDR		---	---	---	---	--/--	----			----------
23	111800Z	24.3N 128.8E	LND RDR		---	---	---	---	--/--	----			----------
24	111900Z	24.4N 128.8E	LND RDR		---	---	---	---	--/--	----			----------
25	112000Z	24.5N 128.8E	LND RDR		---	---	---	---	--/--	----			----------
26	112100Z	24.6N 128.7E	54-P-10---	700MB	095	---	944	2585	17/14	CIRC	----	25	OPEN NW
27	112200Z	24.6N 128.8E	LND RDR		---	---	---	---	--/--	----			----------
28	120000Z	24.8N 129.0E	LND RDR		---	---	---	---	--/--	----			----------
29	120230Z	25.1N 128.8E	54-P-02---	700MB	065	080	950	2650	20/14	CIRC	----	20	5NM THK, OPEN SW-NW
30	120559Z	25.2N 129.5E	SLTLS	STG X	DIA 0	CAT 4							----------
31	120700Z	25.4N 128.9E	LND RDR		---	---	---	---	--/--	----			----------
32	120800Z	25.7N 129.0E	LND RDR		---	---	---	---	--/--	----			----------
33	120900Z	25.8N 129.1E	LND RDR		---	---	---	---	--/--	----			----------
34	120925Z	25.8N 129.2E	VW-P-15---		---	---	---	---	--/--	----			----------
35	121000Z	25.9N 129.2E	LND RDR		---	---	---	---	--/--	----			----------
36	121018Z	25.9N 129.1E	VW-P-02---		---	100	950	---	28/23	CIRC	----	22	5NM THK, OPEN W
37	121100Z	26.0N 129.1E	LND RDR		---	---	---	---	--/--	----			----------
38	121300Z	26.2N 129.0E	LND RDR		---	---	---	---	--/--	----			----------
39	121400Z	26.3N 129.0E	LND RDR		---	---	---	---	--/--	----			----------
40	121445Z	26.3N 129.0E	VW-P-02---		---	---	---	---	--/--	CIRC	----	14	CLSD
41	121500Z	26.4N 129.0E	LND RDR		---	---	---	---	--/--	----			----------
42	121700Z	26.6N 129.0E	LND RDR		---	---	---	---	--/--	----			----------
43	121800Z	26.7N 128.9E	LND RDR		---	---	---	---	--/--	----			----------
44	121900Z	26.8N 128.9E	LND RDR		---	---	---	---	--/--	----			----------
45	122000Z	26.9N 128.9E	LND RDR		---	---	---	---	--/--	----			----------
46	122100Z	26.9N 129.0E	54-P-02---	700MB	085	---	949	2682	17/11	CONC		40-20	OUTER-CLSD, INNER-OPEN W-N
47	122300Z	27.0N 129.0E	LND RDR		---	---	---	---	--/--	----			----------
48	130030Z	27.2N 129.2E	LND RDR		---	---	---	---	--/--	----			----------

TYPHOON WILDA

EYE FIXES CYCLONE 10

FIX NO.	TIME	POSIT	UNIT-METHOD-ACCY	FLT LVL	FLT LVL WND	OBS SFC WND	OBS MIN SLP	MIN 700MB HGT	FLT LVL TT/TD	EYE FORM	ORIEN-TATION	EYE DIA	CHARACTER WALL CLOUD
49	130300Z	27.5N 129.[illegible]E	54-P-03---	700MB	100	100	941	2594	18/10	CIRC	----	15	OPEN NW-NE
50	130500Z	28.0N 129.1E	LND RDR		---	---	---	---	--/--	----			----------
51	130600Z	28.2N 129.0E	LND RDR		---	---	---	---	--/--	----			----------
52	130657Z	28.0N 129.2E	SLTLS	STG X	DIA 04		CAT 4						----------
53	130700Z	28.3N 129.1E	LND RDR		---	---	---		--/--	----			----------
54	130924Z	28.4N 129.1E	VW-P-01---	850MB	---	085	945	2615	19/12	CIRC	----	30	CLSD,18NM THK
55	131100Z	28.0N 128.8E	LND RDR		---	---	---	---	--/--	----			----------
56	131200Z	28.7N 128.8E	LND RDR		---	---	---	---	--/--	----			----------
57	131300Z	28.8N 128.9E	LND RDR		---	---	---	---	--/--	----			----------
58	131410Z	28.9N 129.1E	VW-P-01---	850MB	---	---	941	2603	21/12	CIRC	----	30	15NM THK, NW&E QUAD
59	131500Z	29.2N 128.9E	LND RDR		---	---	---	---	--/--	----			----------
60	131600Z	29.4N 128.8E	LND RDR		---	---	---	---	--/--	----			----------
61	131800Z	29.8N 128.7E	LND RDR		---	---	---	---	--/--	----			----------
62	132000Z	30.1N 128.5E	LND RDR		---	---	---	---	--/--	----			----------
63	132200Z	30.3N 128.5E	LND RDR		---	---	---	---	--/--	----			----------
64	132300Z	30.4N 128.6E	LND RDR		---	---	---	---	--/--	----			----------
65	140100Z	30.6N 128.7E	LND RDR		---	---	---	---	--/--	----			----------
66	140300Z	30.9N 128.7E	LND RDR		---	---	---	---	--/--	----			----------
67	140300Z	30.9N 128.7E	54-P-02---	700MB	095	085	950	2652	20/--	CIRC	----	35	CLSD, 5NM THK
68	140400Z	31.0N 128.7E	LND RDR		---	---	---	---	--/--	----			----------
69	140400Z	31.0N 128.8E	LND RDR		---	---	---	---	--/--	----			----------
70	140500Z	31.2N 128.8E	LND RDR		---	---	---	---	--/--	----			----------
71	140500Z	31.2N 128.9E	LND RDR		---	---	---	---	--/--	----			----------
72	140558Z	31.5N 129.0E	SLTLS	STG X	DIA 0		CAT 4						----------
73	140700Z	31.5N 129.1E	LND RDR		---	---	---	---	--/--	----			----------
74	140700Z	31.6N 129.1E	LND RDR		---	---	---	---	--/--	----			----------
75	140800Z	31.7N 129.2E	LND RDR		---	---	---	---	--/--	----			----------
76	140800Z	31.8N 129.2E	LND RDR		---	---	---	---	--/--	----			----------
77	140900Z	31.9N 129.2E	LND RDR		---	---	---	---	--/--	----			----------
78	140900Z	31.9N 129.2E	LND RDR		---	---	---	---	--/--	----			----------
79	140901Z	31.8N 129.4E	VW-P-01---	700MB	---	075	941	2615	21/16	CIRC	----	23	4-12NM THK, OPEN SW
80	141000Z	32.1N 129.3E	LND RDR		---	---	---	---	--/--	----			----------
81	141000Z	32.1N 129.3E	LND RDR		---	---	---	---	--/--	----			----------
82	141100Z	32.2N 129.4E	LND RDR		---	---	---	---	--/--	----			----------
83	141100Z	32.2N 129.5E	LND RDR		---	---	---	---	--/--	----			----------
84	141200Z	32.4N 129.6E	LND RDR		---	---	---	---	--/--	----			----------
85	141200Z	32.5N 129.5E	LND RDR		---	---	---	---	--/--	----			----------
86	141230Z	32.7N 129.8E	LND RDR		---	---	---	---	--/--	----			----------
87	141300Z	32.6N 129.6E	LND RDR		---	---	---	---	--/--	----			----------
88	141400Z	32.9N 130.1E	LND RDR		---	---	---	---	--/--	----			----------
89	141400Z	32.8N 129.9E	LND RDR		---	---	---	---	--/--	----			----------
90	141405Z	32.6N 130.[illegible]E	VW-P-01---	700MB	---	---	946	2731	18/13	CIRC	----	30	12NM THK, OPEN SW QUAD
91	141500Z	33.1N 130.2E	LND RDR		---	---	---	---	--/--	----			----------
92	141500Z	33.0N 130.1E	LND RDR		---	---	---	---	--/--	----			----------
93	141600Z	33.2N 130.2E	LND RDR		---	---	---	---	--/--	----			----------
94	141600Z	33.3N 130.3E	LND RDR		---	---	---	---	--/--	----			----------
95	141700Z	33.4N 130.4E	LND RDR		---	---	---	---	--/--	----			----------
96	141702Z	33.5N 130.6E	LND RDR		---	---	---	---	--/--	----			----------

TYPHOON WILDA
EYE FIXES CYCLONE 10

FIX NO.	TIME	POSIT	UNIT-METHOD-ACCY	FLT LVL	FLT LVL WND	OBS SFC WND	OBS MIN SLP	MIN 700MB HGT	FLT LVL TT/TO	EYE FORM	ORIEN-TATION	EYE DIA	CHARACTER WALL CLOUD
97	141800Z	33.8N 130.8E	LND RDR		---	---	---	---	--/--	----			----------
98	141800Z	33.8N 130.7E	LND RDR		---	---	---	---	--/--	----			----------
99	141900Z	33.9N 131.1E	LND RDR		---	---	---	---	--/--	----			----------
100	142000Z	34.0N 131.4E	LND RDR		---	---	---	---	--/--	----			----------
101	142055Z	34.7N 131.6E	54---08---	500MB	051	---	---	---	--/--	----			----------
102	142100Z	34.5N 131.5E	LND RDR		---	---	---	---	--/--	----			----------
103	142200Z	34.7N 131.9E	LND RDR		---	---	---	---	--/--	----			----------
104	150000Z	35.3N 132.3E	LND RDR		---	---	---	---	--/--	----			----------
105	150245Z	35.7N 131.9E	54---02---	700MB	045	---	---	3066	--/--	----			NEG W/C
106	150800Z	38.4N 136.8E	LND RDR		---	---	---	---	--/--	----			----------
107	151125Z	39.8N 136.8E	VW---03---		---	030	976	---	25/22	----			NEG W/C
108	151300Z	40.9N 139.1E	LND RDR		---	---	---	---	--/--	----			----------
109	151400Z	41.5N 139.4E	LND RDR		---	---	---	---	--/--	----			----------

TYPHOON WILDA

TROPICAL CYCLONE 10 -- 8/8/2300Z TO 8/15/1700Z
POSITION AND FORECAST VERIFICATION DATA

WARN NO.	DTG	WARNING POSIT LAT	WARNING POSIT LONG	BEST TRACK LAT	BEST TRACK LONG	24 HR FCST LAT	24 HR FCST LONG	24 HR ERROR DEG DIST	48 HR FCST LAT	48 HR FCST LONG	48 HR ERROR DEG DIST	72 HR FCST LAT	72 HR FCST LONG	72 HR ERROR DEG DIST
01	09/0500Z	22.8N	131.5E	22.8N	131.5E	22.8N	127.9E	310-0102	22.8N	124.4E	264-0252	-----	------	--------
02	09/1100Z	22.6N	130.3E	22.5N	130.4E	21.9N	124.8E	269-0246	22.2N	118.8E	261-0558	23.0N	113.3E	258-0822
03	09/1700Z	22.3N	129.1E	22.2N	129.9E	21.9N	123.3E	265-0324	22.3N	117.3E	259-0642	-----	------	--------
04	09/2300Z	21.8N	129.5E	21.7N	129.4E	20.6N	126.6E	228-0186	20.0N	122.4E	232-0456	20.6N	118.3E	237-0708
05	10/0500Z	21.7N	129.3E	21.7N	129.3E	21.7N	128.8E	184-0096	21.9N	127.1E	207-0228	-----	------	--------
06	10/1100Z	22.0N	129.5E	22.0N	129.3E	22.7N	129.0E	169-0066	27.1N	125.0E	202-0144	25.0N	124.0E	231-0348
07	10/1700Z	22.2N	129.3E	22.4N	129.2E	23.3N	128.0E	211-0078	24.5N	125.0E	240-0246	-----	------	--------
08	10/2300Z	22.6N	129.0E	22.7N	129.1E	23.7N	127.1E	236-0114	25.2N	123.6E	248-0312	27.1N	120.3E	246-0480
09	11/0500Z	23.3N	129.0E	23.3N	129.0E	25.4N	127.8E	275-0060	28.1N	125.1E	271-0210	-----	------	--------
10	11/1100Z	23.6N	128.9E	23.8N	128.8E	25.5N	127.7E	211-0030	27.9N	125.4E	256-0192	29.8N	122.4E	248-0390
11	11/1700Z	24.4N	128.6E	24.5N	128.8E	26.6N	127.1E	270-0102	28.7N	124.3E	259-0234	-----	------	--------
12	11/2300Z	24.8N	128.6E	24.8N	128.9E	26.7N	127.9E	241-0060	29.1N	127.4E	218-0096	31.3N	128.7E	216-0276
13	12/0500Z	25.3N	128.8E	25.3N	129.0E	27.1N	128.6E	204-0054	28.9N	128.3E	170-0138	-----	------	--------
14	12/1100Z	26.0N	129.3E	26.0N	128.1E	27.6N	132.7E	108-0198	29.4N	137.1E	114-0426	32.8N	145.3E	134-0564
15	12/1700Z	26.6N	129.0E	26.6N	129.0E	28.6N	130.2E	126-0090	30.8N	134.7E	125-0264	-----	------	--------
16	12/2300Z	27.1N	129.0E	27.2N	129.0E	29.5N	128.9E	167-0054	31.9N	128.9E	218-0246	35.7N	130.1E	--------
17	13/0500Z	28.0N	129.0E	28.0N	129.1E	35.8N	136.0E	053-0450	-----	------	--------	-----	------	--------
18	13/1100Z	28.7N	129.0E	28.7N	129.1E	32.9N	129.6E	010-0036	38.0N	133.0E	245-0204	-----	------	--------
19	13/1700Z	29.4N	129.0E	29.5N	128.8E	33.8N	129.9E	314-0030	38.5N	133.5E	229-0378	-----	------	--------
20	13/2300Z	30.4N	128.5E	30.4N	128.6E	34.1N	130.2E	235-0102	39.2N	134.2E	--------	-----	------	--------
21	14/0500Z	31.2N	128.6E	31.2N	128.8E	34.7N	130.8E	230-0234	39.9N	134.6E	--------	-----	------	--------
22	14/1100Z	32.1N	129.5E	32.3N	129.5E	36.4N	133.1E	226-0258	42.7N	136.7E	--------	-----	------	--------
23	14/1700Z	33.4N	130.5E	33.4N	130.4E	37.6N	134.0E	221-0402	43.9N	137.0E	--------	-----	------	--------
24	14/2300Z	34.9N	132.0E	35.1N	132.0E	43.0N	136.8E	--------	-----	------	--------	-----	------	--------
25	15/0500Z	37.0N	134.9E	37.3N	134.5E	-----	------	--------	-----	------	--------	-----	------	--------
26	15/1100Z	39.9N	138.0E	39.5N	137.0E	-----	------	--------	-----	------	--------	-----	------	--------
27	15/1700Z	42.9N	140.8E	42.7N	139.7E	-----	------	--------	-----	------	--------	-----	------	--------

AVERAGE 24 HOUR ERROR - 0146 MI. 146.6
AVERAGE 48 HOUR ERROR - 0290 MI.
AVERAGE 72 HOUR ERROR - 0512 MI.

D. TYPHOON ANITA 15 AUG 2300Z-22 AUG 0500Z

1. STATISTICS

   a. Number of Warnings Issued - 26

   b. Number of Warnings with Typhoon Intensity - 19

   c. Distance Traveled During Warning Period - 2,001 MI

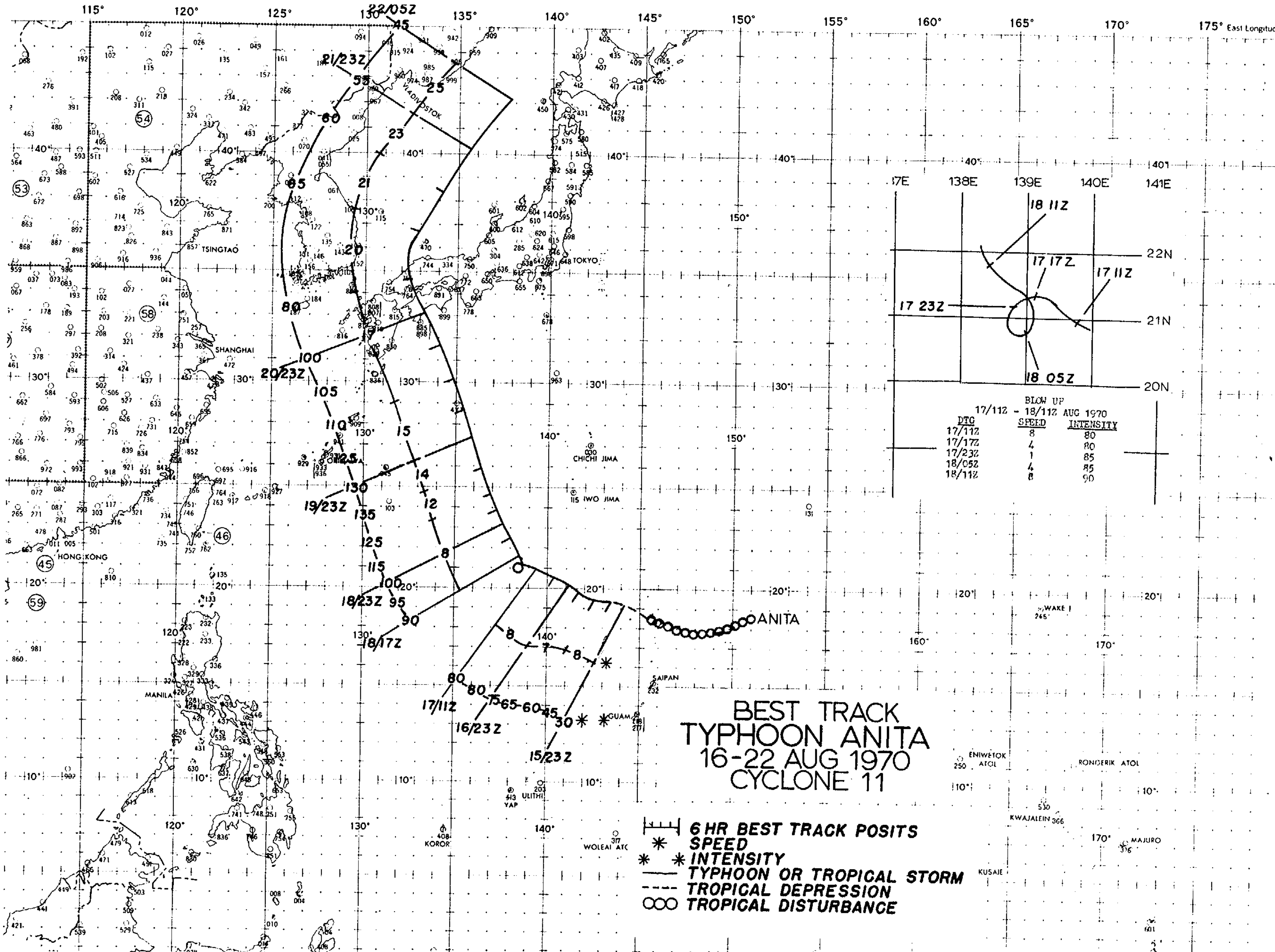
2. CHARACTERISTICS AS A TYPHOON

   a. Minimum Observed SLP - 912 MBS at 19/2055Z

   b. Minimum Observed 700 MB Height - 2325 M at 19/2055Z

   c. Maximum Surface Wind - 135 KTS (From Best Track)

   d. Maximum Radius of Surface Circulation - 480 MI


BEST TRACK
TYPHOON ANITA
16-22 AUG 1970
CYCLONE 11
6 HR BEST TRACK POSITS
SPEED
INTENSITY
TYPHOON OR TROPICAL STORM
TROPICAL DEPRESSION
TROPICAL DISTURBANCE
ANITA
BLOW UP
17/11Z - 18/11Z AUG 1970
DTG SPEED INTENSITY
17/11Z 8 80
17/17Z 4 80
17/23Z 1 85
18/05Z 4 85
18/11Z 8 90
18 11Z
17 17Z
17 11Z
17 23Z
18 05Z
22N
21N
20N
22/05Z
21/23Z
20/23Z
19/23Z
18/23Z
18/17Z
17/11Z
16/23Z
15/23Z
TOKYO
VLADIVOSTOK
TSINGTAO
SHANGHAI
HONG KONG
MANILA
CHICHI JIMA
IWO JIMA
SAIPAN
GUAM
ULITHI
YAP
KOROR
WOLEAI ATOL
WAKE I
ENIWETOK ATOL
RONGERIK ATOL
KWAJALEIN
MAJURO
KUSAIE
East Longitude

3. TYPHOON ANITA NARRATIVE

As early as the 11th upper air reports from Marcus and Wake Islands plus satellite pictures indicated an upper level circulation in existence between the two islands. Two days later an ESSA-8 view disclosed the system to have drifted south of Marcus and enhanced in convective activity. Ship data indicated the low aloft had reflected downward into the surface pressure pattern as an induced wave.

This wave disturbance passed through the Northern Marianas chain during the night of the 15th to 16th with evidence of a developing circulation. A reconnaissance aircraft investigated the system the following afternoon and located a closed center with 995 mb central pressure 140 miles northwest of Pagan Island and Tropical Storm Anita was named.

Anita proceeded west northwest and intensified to typhoon strength within 18 hours while shifting to a more northerly course on the 17th. The ridge line north of the typhoon began to weaken considerably between Okinawa and Iwo Jima as a reflection of a slow moving trough in the westerlies east of Korea. Meanwhile heights began to build east of Japan with the establishment of a strong center of action for the subtropical ridge to the northeast of Anita. This set up steering conditions which resulted in a northwest path towards the Japanese coastline for the next three days.

While southwest of Iwo Jima on the 18th, Anita began to approach a 200 mb trough over the Sea of Japan extending through the Northern Ryukyu's. As this trough provided an efficient evacuation mechanism for the transfer of mass to the westerlies, the central pressure began to respond. In the following 36 hours dropsonde measurements showed a progressive fall of 55 mb. Reconnaissance aircraft radar presentations and infra-red satellite view of the storm during the night of the 19-20th indicated Anita had become highly organized in character (Figure 5-8). The storm reached its peak intensity while attaining super typhoon strength during the morning hours of the 20th as aerial reconnaissance registered a 912 mb surface pressure in the eye some 270 mi northwest of Iwo Jima (Figure 5-9).

At this point Anita started to increase her forward speed to 15 knots and later to 17 knots due to the increased southerly flow created between a strong mid-tropospheric high to the northeast and a cut off low in the East China Sea. The eye of the typhoon crossed the coastline of Western Shikoku about 40 N.M. southwest of Kochi City during the late morning hours of the 21st with an accompanying storm surge of 7.7 feet flooding parts of the city. At this time Anita had filled and wind strength was near 105 knots. Maximum sustained wind

FIGURE 5-8 NIMBUS IV NIGHTTIME INFRA-RED VIEW OF TYPHOON ANITA (ORBIT 1783) 19 AUGUST. A TROPICAL DISTURBANCE IS DEPICTED NORTHEAST OF THE TYPHOON EAST OF THE JAPANESE ISLANDS.

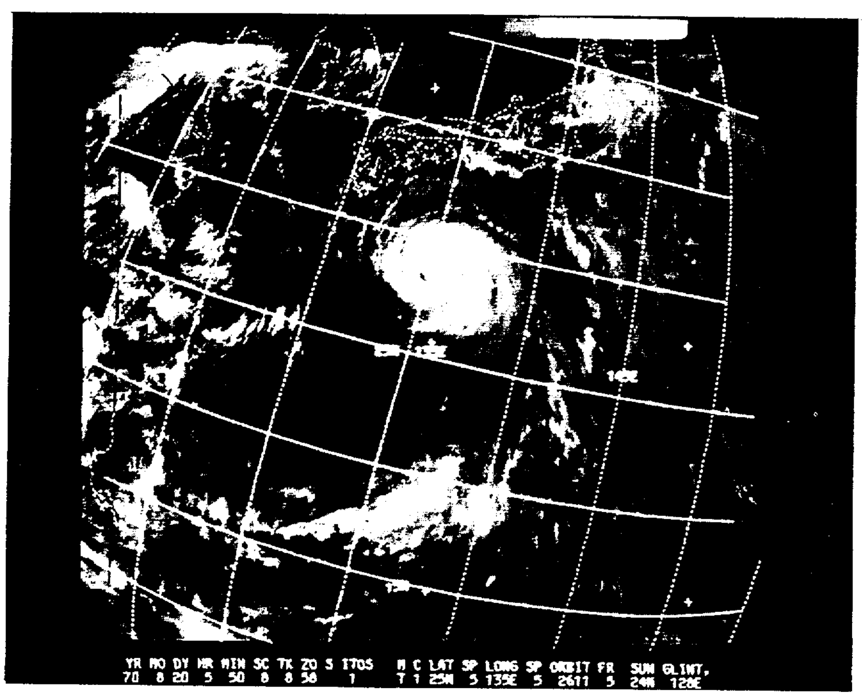


FIGURE 5-9 ANITA SOUTH OF SHIKOKU ISLAND WITH SUPER TYPHOON WINDS AS DISPLAYED TO ITOS-1 ON THE AFTERNOON OF 20 AUGUST.

report occurred at Murotomisaki Weather Station registering 100 knots and gusts to 124 knots about 60 miles east of the center. Lowest pressure measured in the area was at Cape Ashizuri 15 miles west of the center with 962.3 mb.

At least 31 vessels were reported sunk including the 2,739 ton Japanese ship Koyo Maru along the coast of Japan while heavy rains (up to 15 inches) caused floods and landslides inland. Statistics reveal at least 23 storm-related deaths, 556 injured and over 5,000 houses partially or totally destroyed.

In response to a major trough moving off the China coast, the typhoon recurved sharply after passage over Hiroshima and entrance into the Sea of Japan. On her northeast course, at a rate greater than 20 knots, Anita quickly lost typhoon intensity late on the 21st. She transformed to an extratropical system as she passed west of Hokkaido by the 22nd.

TYPHOON ANITA

EYE FIXES CYCLONE 11

FIX NO.	TIME	POSIT	UNIT-METHOD-ACCY	FLT LVL	FLT LVL WND	OBS SFC WND	OBS MIN SLP	MIN 700MB HGT	FLT LVL TT/TO	EYE FORM	ORIEN-TATION	EYE DIA	CHARACTER WALL CLOUD
1	160222Z	19.3N 143.6E	54-P-25---		040	045	995	---	26/24	----			NEG WALL
2	160551Z	19.5N 143.0E	SLTLS	STG B	DIA --	CAT -							----------
3	160600Z	18.8N 142.3E	ACFT RDR		---	---	---	---	--/--	----			----------
4	160903Z	19.2N 142.4E	VW-P-10---	0160M	050	---	---	---	--/--	CIRC	----	10	OPEN TO NW
5	161211Z	19.3N 141.9E	VW-P-05---		---	---	---	---	--/--	CIRC	----	15	CLSD WALL 4NM THK
6	161405Z	19.3N 141.7E	VW-P-10---		---	---	---	---	--/--	CIRC	----	17	OPEN TO N
7	162100Z	19.7N 141.4E	54-P-05---	700MB	055	075	978	2914	16/12	CIRC	----	22	5NM THK, OPEN W QUAD
8	170300Z	20.3N 140.6E	54-P-05---	700MB	072	080	976	2920	19/13	CIRC	----	40	NEG W/C
9	170456Z	19.5N 139.5E	SLTLS	STG X	DIA 0	CAT 3							----------
10	170900Z	20.8N 139.8E	VW-P-05---	0200M	---	055	977	---	28/23	CIRC	----	18	NEG W/C
11	171235Z	21.0N 139.5E	VW-P-02---	0200M	---	055	977	---	28/24	ELIP	N-S	36X24	8NM THK N SEMICIR
12	171400Z	21.0N 139.1E	VW-P-10---		---	---	---	---	--/--	ELIP	N-S	35X25	----------
13	172100Z	21.1N 139.0E	54-P-05---	700MB	070	080	960	2810	23/15	----			OPEN NE-NW
14	180430Z	20.9N 138.9E	54-P-10---	700MB	080	075	962	2829	16/11	----			CLSD
15	180553Z	21.5N 138.0E	SLTLS	STG X	DIA 0	CAT 3							----------
16	180900Z	21.4N 138.5E	VW-P-05---		057	---	---	---	--/--	ELIP	NE-SW	20X14	CLSD
17	181340Z	21.9N 138.3E	VW-P-03---		065	100	965	---	27/23	CIRC	----	20	CLSD
18	182050Z	22.8N 137.8E	54-P-07---	700MB	087	070	947	2643	16/12	CIRC	----	20	OPEN SSW-W
19	190300Z	23.6N 137.4E	54-P-08---	700MB	110	095	924	2435	20/12	CIRC	----	18	CLSD, 5NM THK
20	190454Z	23.5N 137.0E	SLTLS	STG X	DIA 0	CAT 4							----------
21	190925Z	24.5N 137.1E	VW-P-10---		---	---	---	---	--/--	----			CLSD, 5NM THK
22	191005Z	24.5N 137.2E	VW-P-05---	700MB	---	---	921	2417	--/--	CIRC	----	14	CLSD, 5NM THK
23	191435Z	25.2N 136.7E	VW-P-10---		---	---	---	---	--/--	----			CLSD, 5NM THK
24	192055Z	26.3N 136.6E	54-P-05---	700MB	110	130	912	2325	22/15	CIRC	----	18	CLSD
25	200300Z	28.0N 135.6E	54-P-30---	700MB	100	110	924	2430	20/14	CIRC	----	20	CLSD
26	200425Z	27.5N 135.5E	ACFT RDR		---	---	---	---	--/--	----			----------
27	200520Z	28.5N 135.0E	SLTLS	STG X	DIA 0	CAT 4							----------
28	200800Z	29.4N 134.9E	LND RDR		---	---	---	---	--/--	----			----------
29	200857Z	29.5N 135.2E	VW-P-05---		075	---	---	---	--/--	CIRC	----	11	CLSD, APRD BKN S SEMICIR
30	200900Z	29.5N 134.9E	LND RDR		---	---	---	---	--/--	----			----------
31	201425Z	30.7N 134.3E	VW-P-03---	700MB	075	---	950	2658	16/12	CIRC	----	20	CLSD, 11NM THK
32	201430Z	30.4N 134.2E	ACFT RDR		---	---	---	---	--/--	----			----------
33	201600Z	31.2N 133.9E	ACFT RDR		---	---	---	---	--/--	----			----------
34	201658Z	31.4N 133.7E	ACFT RDR		---	---	---	---	--/--	----			----------
35	201700Z	31.4N 133.8E	ACFT RDR		---	---	---	---	--/--	----			----------
36	201800Z	31.5N 133.7E	ACFT RDR		---	---	---	---	--/--	----			----------
37	201800Z	31.6N 133.6E	ACFT RDR		---	---	---	---	--/--	----			----------
38	201900Z	31.8N 133.7E	LND RDR		---	---	---	---	--/--	----			----------
39	202000Z	32.1N 133.5E	LND RDR		---	---	958 ---	---	--/--	----			----------
40	202100Z	32.0N 134.0E	54-P-05---	700MB	070	080	950	2725	17/13	CONC		50-20	OUTER-OPEN W-NW, INNER-OPEN SW-W
41	202100Z	32.4N 133.3E	LND RDR		---	---	---	---	--/--	----			----------
42	202200Z	32.5N 133.3E	LND RDR		---	---	---	---	--/--	----			----------
43	202230Z	32.7N 133.3E	LND RDR		---	---	---	---	--/--	----			----------
44	202300Z	33.0N 133.2E	LND RDR		---	---	---	---	--/--	----			----------
45	210000Z	33.3N 132.9E	LND RDR		---	---	---	---	--/--	----			----------
46	210200Z	34.2N 132.5E	LND RDR		---	---	---	---	--/--	----			----------
47	210300Z	34.2N 132.6E	54-P-06---	500MB	075	---	---	---	03/00	----			NEG W/C
48	210500Z	34.9N 132.2E	LND RDR		---	---	---	---	--/--	----			----------

TYPHOON ANITA

EYE FIXES CYCLONE 11

FIX NO.	TIME	POSIT	UNIT-METHOD-ACCY	FLT LVL	FLT LVL WND	OBS SFC WND	OBS MIN SLP	MIN 700MB HGT	FLT LVL TT/TD	EYE FORM	ORIEN-TATION	EYE DIA	CHARACTER WALL CLOUD
49	210700Z	35.7N 132.4E	LND RDR		---	---	---	---	--/--	----			----------
50	210800Z	35.8N 132.5E	LND RDR		---	---	---	---	--/--	----			----------
51	211000Z	35.1N 132.7E	LND RDR		---	---	---	---	--/--	----			----------
52	211024Z	36.1N 132.3E	VW---03---	700MB	057	---	993	3024	15/09	----			----------
53	211200Z	36.7N 132.9E	LND RDR		---	---	---	---	--/--	----			----------
54	211215Z	36.8N 132.8E	VW--------	700MB	066	---	---	---	--/--	----			NEG W/C
55	211300Z	35.9N 133.1E	LND RDR		---	---	---	---	--/--	----			----------
56	211400Z	37.5N 133.0E	LND RDR		---	---	---	---	--/--	----			----------
57	211407Z	37.2N 133.4E	VW---01---	700MB	000	---	991	3051	13/11	----			NEG W/C
58	212100Z	39.4N 135.1E	54---10---		065	---	---	---	--/--	CIRC	----	10	----------

TYPHOON ANITA

TROPICAL CYCLONE 11 -- 8/15/2300Z TO 8/22/0500Z
POSITION AND FORECAST VERIFICATION DATA

WARN		WARNING POSIT		BEST TRACK		24 HR FCST		24 HR ERROR	48 HR FCST		48 HR ERROR	72 HR FCST		72 HR ERROR
NO.	DTG	LAT	LONG	LAT	LONG	LAT	LONG	DEG DIST	LAT	LONG	DEG DIST	LAT	LONG	DEG DIST
01	15/2300Z	19.4N	143.6E	19.1N	144.4E	21.7N	141.7E	~~010-0096~~	-----	------	--------	-----	------	--------
02	16/0500Z	20.1N	143.2E	19.3N	143.5E	22.2N	141.2E	027-0102	-----	------	--------	-----	------	--------
03	16/1100Z	19.2N	142.2E	19.3N	142.5E	19.4N	138.8E	202-0096	20.2N	135.5E	242-0186	21.3N	132.8E	229-0306
04	16/1700Z	19.3N	141.2E	19.6N	141.7E	19.7N	137.5E	227-0120	20.6N	134.2E	244-0240	-----	------	--------
05	16/2300Z	19.8N	141.1E	20.1N	141.1E	21.2N	138.5E	288-0018	22.7N	135.5E	259-0120	24.3N	132.9E	226-0252
06	17/0500Z	20.5N	140.4E	20.6N	140.3E	22.6N	137.7E	324-0120	24.6N	135.1E	288-0132	-----	------	--------
07	17/1100Z	21.0N	139.6E	20.9N	139.5E	23.1N	136.8E	313-0120	25.3N	134.3E	283-0150	27.7N	132.7E	217-0180
08	17/1700Z	21.4N	138.9E	21.1N	139.1E	23.4N	136.2E	300-0114	25.7N	133.9E	266-0156	-----	------	--------
09	17/2300Z	21.2N	138.9E	21.1N	138.9E	21.9N	137.8E	175-0072	23.4N	135.7E	188-0234	25.0N	133.9E	175-0480
10	18/0500Z	20.9N	138.9E	20.9N	139.0E	21.3N	138.7E	155-0168	22.3N	137.2E	167-0390	-----	------	--------
11	18/1100Z	21.6N	138.4E	21.7N	138.5E	23.2N	136.8E	188-0090	25.8N	134.7E	180-0258	28.3N	133.4E	177-0492
12	18/1700Z	22.1N	138.0E	22.4N	138.1E	24.0N	136.8E	180-0114	26.6N	135.5E	164-0300	-----	------	--------
13	18/2300Z	23.1N	137.7E	23.1N	137.7E	26.3N	135.9E	197-0060	30.5N	134.5E	156-0162	36.5N	136.2E	197-0228
14	19/0500Z	23.9N	137.2E	23.9N	137.4E	27.6N	135.5E	180-0066	32.6N	134.1E	146-0150	-----	------	--------
15	19/1100Z	24.7N	136.9E	24.7N	137.1E	28.4N	135.2E	169-0102	33.9N	134.0E	160-0162	41.5N	136.5E	--------
16	19/1700Z	25.4N	136.5E	25.9N	136.8E	29.0N	134.7E	166-0150	33.6N	132.1E	200-0294	-----	------	--------
17	19/2300Z	26.6N	136.5E	27.3N	136.3E	31.2N	135.2E	134-0144	37.8N	134.8E	197-0150	47.0N	139.5E	--------
18	20/0500Z	28.3N	135.7E	28.7N	135.6E	36.5N	134.1E	036-0132	45.0N	137.5E	003-0162	-----	------	--------
19	20/1100Z	30.1N	134.9E	30.1N	134.8E	39.2N	134.9E	030-0180	-----	------	--------	-----	------	--------
20	20/1700Z	31.5N	134.3E	31.5N	133.9E	38.5N	134.5E	046-0012	-----	------	--------	-----	------	--------
21	20/2300Z	32.9N	133.2E	33.0N	133.1E	40.3N	134.6E	277-0048	-----	------	--------	-----	------	--------
22	21/0500Z	34.8N	132.7E	34.7N	132.4E	43.7N	136.2E	330-0096	-----	------	--------	-----	------	--------
23	21/1100Z	36.3N	132.7E	36.5N	132.9E	41.0N	136.1E	--------	-----	------	--------	-----	------	--------
24	21/1700Z	38.0N	133.9E	38.3N	134.2E	43.8N	139.5E	--------	-----	------	--------	-----	------	--------
25	21/2300Z	40.1N	135.7E	40.2N	135.7E	-----	------	--------	-----	------	--------	-----	------	--------
26	22/0500Z	42.2N	137.4E	42.3N	137.4E	-----	------	--------	-----	------	--------	-----	------	--------

AVERAGE 24 HOUR ERROR - 0100 MI. 101.0
AVERAGE 48 HOUR ERROR - 0202 MI.
AVERAGE 72 HOUR ERROR - 0323 MI.

E. TYPHOON BILLIE 23 AUG 0500Z-31 AUG 1100Z

1. STATISTICS

a. Number of Warnings Issued - 34

b. Number of Warnings with Typhoon Intensity - 24

c. Distance Traveled During Warning Period - 1,697 MI

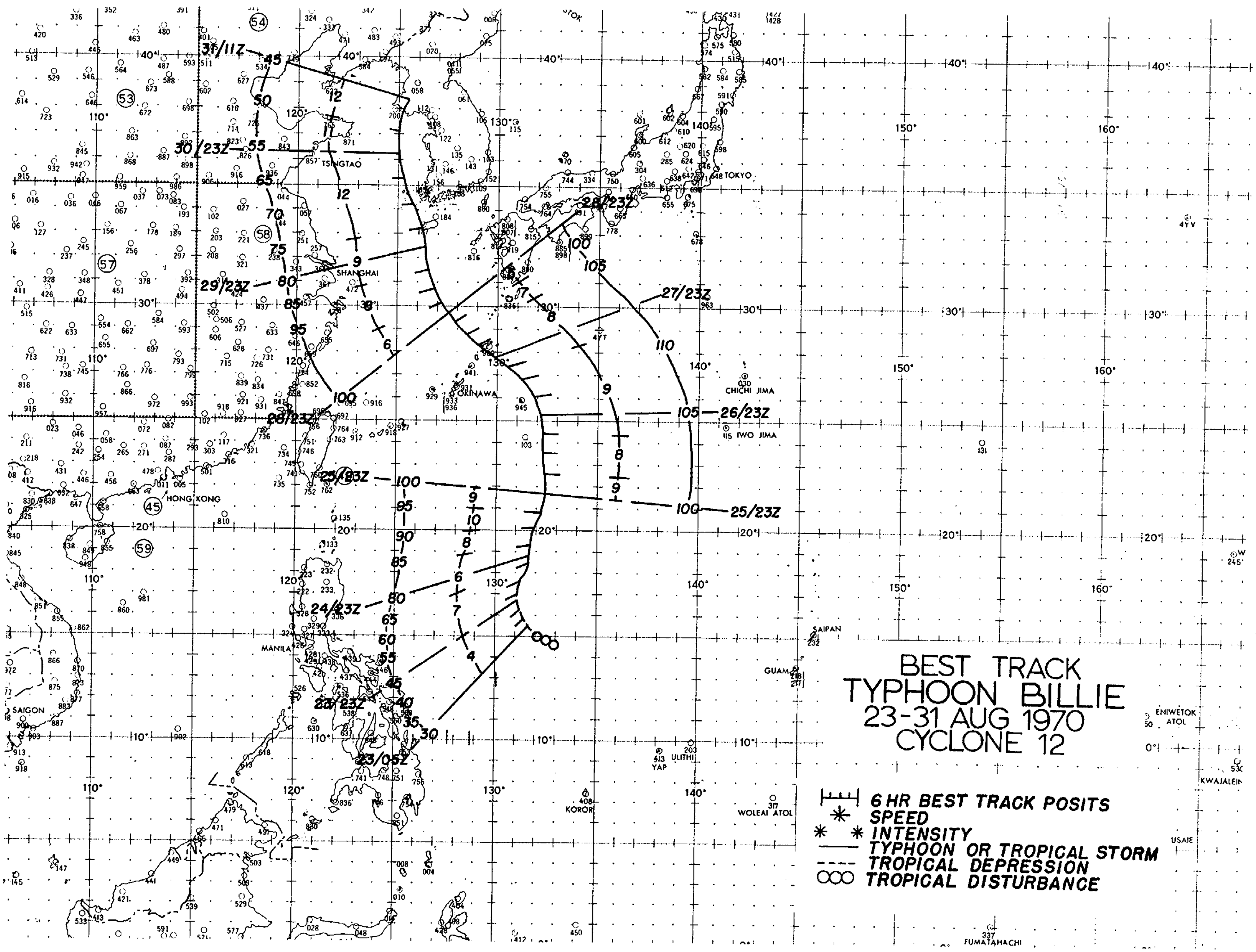
2. CHARACTERISTICS AS A TYPHOON

a. Minimum Observed SLP - 945 MBS at 28/0000Z

b. Minimum Observed 700 MB Height - 2624 M at 28/0000Z

c. Maximum Surface Wind - 110 KTS (From Best Track)

d. Maximum Radius of Surface Circulation - 600 MI


BEST TRACK
TYPHOON BILLIE
23-31 AUG 1970
CYCLONE 12
6 HR BEST TRACK POSITS
SPEED
INTENSITY
TYPHOON OR TROPICAL STORM
TROPICAL DEPRESSION
TROPICAL DISTURBANCE
TSINGTAO
SHANGHAI
HONG KONG
MANILA
SAIGON
OKINAWA
TOKYO
CHICHI JIMA
IWO JIMA
SAIPAN
GUAM
YAP
ULITHI
KOROR
WOLEAI ATOL
ENIWETOK ATOL
KWAJALEIN
USAIE
FUMATAHACHI
31/11Z
30/23Z
29/23Z
28/23Z
27/23Z
26/23Z
25/23Z
24/23Z
23/23Z
23/05Z

3. TYPHOON BILLIE NARRATIVE

Billie formed in the Philippine Sea within the zone of the intertropical trough on August 22nd. Prior to this, extensive cloudiness had been depicted by satellite pictures for several days in this area. The enhanced convection appeared to be generated by increased southwest monsoon flow into the region which apparently had been triggered by the presence of Typhoon Anita in the Northern Philippine Sea.

Upon initial detection of a weak depression by reconnaissance aircraft on the 23rd the storm intensified slowly while drifting northward and reached typhoon force early on the 25th. The westerlies were displaced near 40°N during the latter part of August and steering initially was weak. However, a high cell located east of Guam provided some steering and this combined with the storm's internal steering force for a northward movement of 8 to 9 knots through the 27th.

As heights began to build slowly across Japan, Billie swung to a northwesterly course during the afternoon of the 27th which caused the track to cross through the Ryukyu chain just south of Amami-o-Shima. Prior to passage of the island, Billie reached her lowest pressure of 945 mb and maximum strength of 110 knots.(Figure 5-10)

Heights continued to build over the Sea of Japan and the ridge line receded toward a higher latitude. The typhoon began to turn more northward which eventually took the storm just west of Chiejudo Island and into the Yellow Sea where it paralleled the South Korean coastline. As drier air began to enter the typhoon's circulation, Billie was reduced to tropical storm strength early on the 31st. The storm was being approached by a westerly trough which caused the storm's center to arrive on the Korean coastline west of Kaesong. The tropical system rapidly transformed to extratropical character and accelerated into Manchuria. At least 15 persons were reported killed due to flooding and landslides associated with the storm's rainfall over South Korea.

An unusual aspect during Billie's lifetime was that on five occasions a double wall cloud or concentric eye was observed by reconnaissance crews. The first three instances occurred during the 26th with the outer wall cloud 50 miles in diameter and the inner 7 miles. Later on the 29th, as the storm crossed the East China Sea, 2 cases were observed with an outer diameter of 80 and inner of 20 miles.

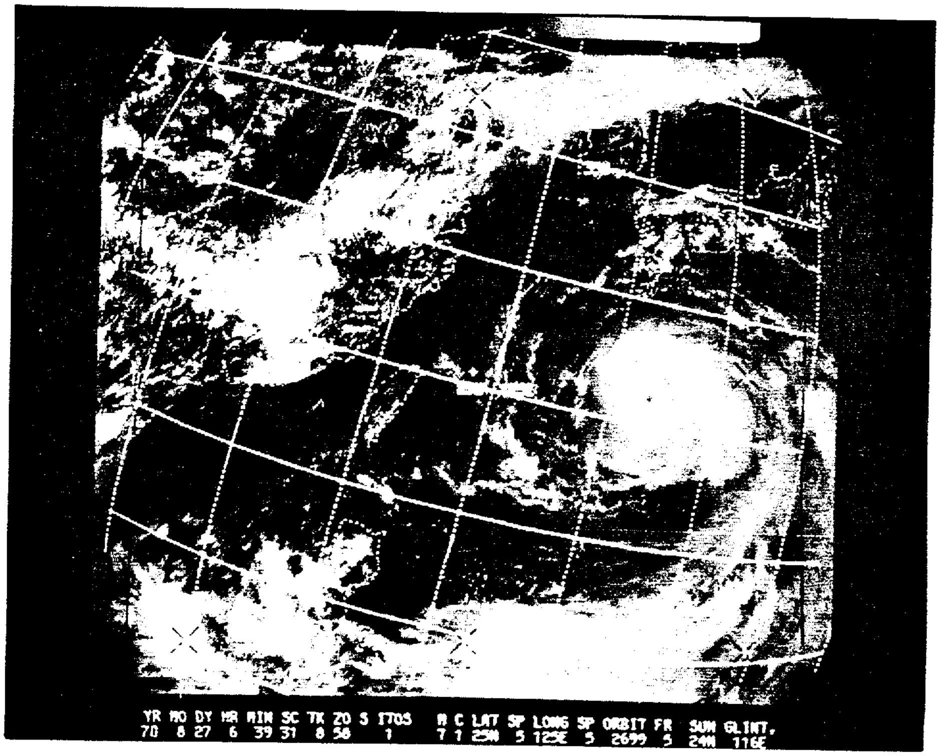


FIGURE 5-10 TOP - TYPHOON BILLIE AS SEEN BY ITOS-1 SATELLITE DURING THE AFTERNOON OF 27 AUGUST.

BOTTOM - THE EYE OF BILLIE ON 28 AUGUST 0400 (JST) - 27/1900 GMT AS VIEWED BY THE NAZE MITSUBISHI RADAR (10.4 CM) ON AMAMI-O-SHIMA ISLAND (COURTESY JAPAN METEROLOGICAL AGENCY). RANGE MARKS ARE AT 100 KM INTERVALS.

TYPHOON BILLIE

EYE FIXES CYCLONE 12

FIX NO.	TIME	POSIT	UNIT-METHOD-ACCY	FLT LVL	FLT LVL WND	OBS SFC WND	OBS MIN SLP	MIN 700MB HGT	FLT LVL TT/TO	EYE FORM	ORIEN-TATION	EYE DIA	CHARACTER WALL CLOUD
1	230215Z	15.6N 131.8E	54-P-05---		023	030	002	3106	26/23	----			NEG W/C
2	232110Z	16.3N 131.5E	54-P-08---	700MB	030	---	990	3015	13/10	----			APRNT W/C FORMG SE QUAD
3	240300Z	16.8N 131.1E	54-P-08---	700MB	042	040	986	2999	15/11	CIRC	----	25	NEG W/C
4	240546Z	17.0N 131.0E	SLTLS	STG X	DIA 02	CAT 2							----------
5	241240Z	17.5N 131.2E	VW-P-20---		---	---	---	---	--/--	----			----------
6	241322Z	17.6N 131.1E	VW-P-07---		---	035	---	---	--/--	CIRC	----	16	W/C FORMG S SEMICIR
7	241457Z	18.0N 131.5E	VW-P-04---	0450M	---	045	980	---	24/21	CIRC	----	24	W/C FORMG S QUAD, 5NM THK
8	242100Z	18.8N 131.6E	54-P-03---	700MB	055	060	966	2829	18/12	CIRC	----	08	W/C FORMG S QUAD
9	250300Z	19.0N 131.7E	54-P-05---	700MB	090	080	---	2813	18/13	CIRC	----	06	W/C BLDG N QUAD
10	250642Z	19.0N 132.5E	SLTLS	STG X	DIA 03	CAT 3							----------
11	250800Z	19.3N 132.7E	VW-------		---	---	---	---	--/--	----			----------
12	250845Z	19.9N 131.9E	VW-P-05---	1500M	103	110	963	---	27/24	CIRC	----	35	8NM THK, OPEN SW
13	251230Z	20.6N 131.6E	VW-P-20---	700MB	095	---	---	---	--/--	CIRC	----	40	CLSD, 8-13NM THK
14	252100Z	21.7N 132.3E	54-P-05---	700MB	070	075	956	2743	18/10	CONC	----	50-7	OUTER-CLSD, INNER-OPEN SW
15	260000Z	22.1N 132.2E	54-P-05---	700MB	075	080	956	2740	17/10	CONC	----	50-8	OUTER-CLSD, INNER-OPEN SW
16	260300Z	22.6N 132.3E	54-P-03---	700MB	075	080	955	2740	18/11	CONC	----	50-6	OUTER CLSD, INNER-OPEN SW
17	260543Z	22.5N 132.0E	SLTLS	STG X	DIA 04	CAT 4							----------
18	260859Z	23.4N 132.1E	VW-P-05---		130	135	960	---	27/24	CIRC	----	35	CLSD, 10NM THK
19	261000Z	23.5N 132.1E	VW--------		---	---	---	---	--/--	----			----------
20	261140Z	23.7N 132.2E	VW-P-05---	700MB	085	---	---	2746	20/12	CIRC	----	25	CLSD
21	261405Z	23.9N 132.3E	VW-P-05---	700MB	100	---	958	2743	19/13	CIRC	----	30	CLSD
22	262100Z	25.0N 132.2E	54-P-05---	700MB	075	085	950	2688	20/15	CIRC	----	35	OPEN SW QUAD
23	270100Z	25.7N 132.1E	LND RDR		---	---	---	---	--/--	----			----------
24	270200Z	26.0N 131.9E	LND RDR		---	---	---	---	--/--	----			----------
25	270300Z	26.0N 131.9E	54-P-05---	700MB	090	100	949	2667	18/14	CIRC	----	40	OPEN S QUAD
26	270400Z	26.1N 131.8E	LND RDR		---	---	---	---	--/--	----			----------
27	270500Z	26.2N 131.8E	LND RDR		---	---	---	---	--/--	----			----------
28	270640Z	26.0N 132.0E	SLTLS	STG X	DIA 0	CAT 4							----------
29	270900Z	26.9N 131.5E	LND RDR		---	---	---	---	--/--	----			----------
30	270924Z	27.0N 131.2E	VW-P-10---		---	---	---	---	--/--	----			----------
31	271013Z	26.8N 131.3E	VW-P-05---		---	085	947	---	27/23	CIRC	----	30	OPEN S, 8NM THK
32	271216Z	27.1N 131.2E	VW-P-10---		---	---	---	---	--/--	----			----------
33	271400Z	27.1N 130.9E	VW-P-05---		---	---	---	---	--/--	CIRC	----	30	OPEN S QUAD, WALL 4NM THK NW-E
34	271500Z	27.3N 130.5E	LND RDR		---	---	---	---	--/--	----			----------
35	271600Z	27.5N 130.4E	LND RDR		---	---	---	---	--/--	----			----------
36	271700Z	27.4N 130.3E	LND RDR		---	---	---	---	--/--	----			----------
37	271741Z	27.3N 130.4E	54-P-05---	500MB	000	---	---	---	03/-4	ELIP	NW-SE	45X3	CLSD
38	271800Z	27.2N 130.1E	LND RDR		---	---	---	---	--/--	----			----------
39	271800Z	27.5N 130.2E	LND RDR		---	---	---	---	--/--	----			----------
40	271900Z	27.8N 130.1E	LND RDR		---	---	---	---	--/--	----			----------
41	271900Z	27.6N 130.2E	LND RDR		---	---	---	---	--/--	----			----------
42	272100Z	27.8N 129.9E	54-P-05---	700MB	058	---	946	2637	17/13	CIRC	----	35	CLSD
43	272230Z	27.9N 129.7E	LND RDR		---	---	---	---	--/--	----			----------
44	272300Z	27.9N 129.6E	LND RDR		---	---	---	---	--/--	----			----------
45	280000Z	27.9N 129.6E	54-P-05---	700MB	085	090	956	2624	17/13	CIRC	----	40	CLSD
46	280000Z	27.9N 129.5E	LND RDR		---	---	---	---	--/--	----			----------
47	280300Z	28.1N 129.2E	54-P-03---	700MB	075	090	948	2634	18/12	CIRC	----	20	CLSD
48	280400Z	28.1N 129.1E	LND RDR		---	---	---	---	--/--	----			----------

TYPHOON BILLIE

EYE FIXES CYCLONE 12

FIX NO.	TIME	POSIT	UNIT-METHOD _ACCY	FLT LVL	FLT LVL WND	OBS SFC WND	OBS MIN SLP	MIN 700MB HGT	FLT LVL TT/TO	EYE FORM	ORIEN-TATION	EYE DIA	CHARACTER WALL CLOUD
49	280500Z	28.2N 129.0E	LND RDR		---	---	---	---	--/--	----			----------
50	280514Z	28.5N 128.5E	SLTLS	STG X	DIA 04		CAT 3						----------
51	280600Z	28.5N 129.0E	LND RDR		---	---	---	---	--/--	----			----------
52	280700Z	28.5N 128.9E	LND RDR		---	---	---	---	--/--	----			----------
53	280840Z	28.6N 128.7E	54-P-02---	700MB	070	060	947	2630	19/15	CIRC	----	28	CLSD, SMALL OPENINGS S
54	280900Z	28.7N 128.7E	LND RDR		---	---	---	---	--/--	----			----------
55	280920Z	28.7N 128.6E	VW-P-05---	700MB	---	065	952	---	20/15	CIRC	----	27	WK W/C S QUAD
56	281100Z	28.8N 128.4E	LND RDR		---	---	---	---	--/--	----			----------
57	281200Z	29.0N 128.1E	VW-P-05---	700MB	070	---	---	2728	19/15	CIRC	----	27	----------
58	281200Z	28.8N 128.3E	LND RDR		---	---	---	---	--/--	----			----------
59	281400Z	28.9N 128.0E	LND RDR		---	---	---	---	--/--	----			----------
60	281500Z	29.0N 128.0E	LND RDR		---	---	---	---	--/--	----			----------
61	281500Z	29.2N 127.8E	VW-P-03---	700MB	070	---	958	2749	17/12	ELIP	NW-SE	20X17	6NM THK, OPEN S AND SE
62	281600Z	29.1N 127.9E	LND RDR		---	---	---	---	--/--	----			----------
63	281700Z	29.2N 127.8E	LND RDR		---	---	---	---	--/--	----			----------
64	281800Z	29.3N 127.7E	LND RDR		---	---	---	---	--/--	----			----------
65	281900Z	29.4N 127.5E	LND RDR		---	---	---	---	--/--	----			----------
66	282000Z	29.5N 127.4E	LND RDR		---	---	---	---	--/--	----			----------
67	282055Z	29.6N 127.6E	54-P-05---	700MB	085	---	949	2670	17/11	CONC		80-20	OUTER-CLSD, INNER-CLSD
68	282100Z	29.5N 127.5E	LND RDR		---	---	---	---	--/--	----			----------
69	282200Z	29.6N 127.3E	LND RDR		---	---	---	---	--/--	----			----------
70	282300Z	29.7N 127.3E	LND RDR		---	---	---	---	--/--	----			----------
71	290000Z	29.8N 127.4E	54-P-05---	700MB	065	065	949	2679	17/13	CONC		80-20	WALL DETERG
72	290200Z	29.9N 127.2E	54-P-05---	700MB	075	080	950	2676	18/13	CIRC	----	20	OPEN W
73	290637Z	30.5N 127.2E	SLTLS	STG X	DIA 0		CAT 3						----------
74	290815Z	30.6N 127.0E	VW-P-03---		---	080	951	---	27/25	CIRC	----	30	OPEN S SEMICIR, NO SEP WALL
75	291130Z	31.1N 127.2E	LND RDR		---	---	---	---	--/--	----			----------
76	291230Z	31.2N 127.0E	LND RDR		---	---	---	---	--/--	----			----------
77	291330Z	31.4N 126.8E	LND RDR		---	---	---	---	--/--	----			----------
78	291400Z	31.0N 127.0E	VW--------		---	---	---	---	--/--	CIRC	----	25	----------
79	291430Z	31.6N 126.8E	LND RDR		---	---	---	---	--/--	----			----------
80	292100Z	32.3N 126.3E	54-P-03---	700MB	085	---	958	2768	17/13	CIRC	----	80	OPEN W-NW, RDR PRESNT POOR
81	292100Z	32.4N 126.7E	LND RDR		---	---	---	---	--/--	----			----------
82	292155Z	32.3N 126.4E	54-P-------		---	---	---	---	--/--	----			----------
83	292200Z	32.6N 126.7E	LND RDR		---	---	---	---	--/--	----			----------
84	292300Z	32.8N 126.8E	LND RDR		---	---	---	---	--/--	----			----------
85	300000Z	32.9N 126.8E	LND RDR		---	---	---	---	--/--	----			----------
86	300100Z	33.1N 126.4E	LND RDR		---	---	---	---	--/--	----			----------
87	300200Z	33.2N 126.4E	LND RDR		---	---	---	---	--/--	----			----------
88	300300Z	32.9N 126.2E	54-P-03---	700MB	002	---	970	2798	16/13	----			NEG W/C
89	300300Z	33.4N 126.4E	LND RDR		---	---	---	---	--/--	----			----------
90	300543Z	33.0N 126.0E	SLTLS	STG X	DIA 0		CAT 2						----------
91	300600Z	33.7N 126.5E	LND RDR		---	---	---	---	--/--	----			----------
92	300700Z	33.8N 126.5E	LND RDR		---	---	---	---	--/--	----			----------
93	300900Z	34.2N 125.8E	LND RDR		---	---	---	---	--/--	----			----------
94	301210Z	34.7N 125.9E	VW--25---	3050M	030	---	---	---	--/--	----			NEG W/C
95	302100Z	35.8N 125.0E	54-P-03---	700MB	045	---	977	2887	12/09	CIRC	----	05	NEG W/C

TYPHOON BILLIE

TROPICAL CYCLONE 12 -- 8/23/0500Z TO 8/31/1100Z
POSITION AND FORECAST VERIFICATION DATA

WARN		WARNING POSIT		BEST TRACK		24 HR FCST		24 HR ERROR	48 HR FCST		48 HR ERROR	72 HR FCST		72 HR ERROR
NO.	DTG	LAT	LONG	LAT	LONG	LAT	LONG	DEG DIST	LAT	LONG	DEG DIST	LAT	LONG	DEG DIST
01	23/0500Z	15.8N	131.5E	15.5N	131.8E	17.3N	129.0E	~~281-0120~~	-----	------	--------	-----	------	--------
02	23/1100Z	16.2N	130.9E	15.8N	131.4E	17.6N	128.3E	270-0162	-----	------	--------	-----	------	--------
03	23/1700Z	16.1N	131.3E	16.1N	131.2E	16.9N	129.8E	229-0126	-----	------	--------	-----	------	--------
04	23/2300Z	16.3N	131.5E	16.5N	131.1E	17.7N	130.7E	217-0078	-----	------	--------	-----	------	--------
05	24/0500Z	17.1N	131.0E	16.9N	131.1E	19.8N	128.8E	280-0168	22.8N	125.9E	270-0354	-----	------	--------
06	24/1100Z	17.4N	131.0E	17.6N	131.2E	19.7N	129.6E	237-0150	22.0N	127.3E	252-0282	24.4N	124.3E	250-0402
07	24/1700Z	18.2N	131.4E	18.3N	131.5E	20.5N	130.7E	258-0084	22.7N	128.8E	243-0204	-----	------	--------
08	24/2300Z	19.0N	131.6E	18.8N	131.6E	22.0N	131.8E	296-0024	24.8N	131.4E	241-0048	27.6N	130.7E	104-0048
09	25/0500Z	19.0N	131.7E	19.3N	131.8E	20.6N	131.9E	189-0126	23.4N	131.7E	180-0156	-----	------	--------
10	25/1100Z	20.1N	132.0E	21.1N	131.9E	22.4N	132.1E	180-0086	25.9N	131.2E	180-0048	29.4N	130.0E	067-0090
11	25/1700Z	20.6N	131.8E	20.8N	132.2E	23.3N	131.8E	197-0060	26.8N	130.8E	161-0036	-----	------	--------
12	25/2300Z	21.9N	132.4E	21.8N	132.3E	25.1N	132.6E	108-0018	28.5N	131.3E	062-0084	31.9N	130.0E	044-0186
13	26/0500Z	22.9N	132.3E	22.7N	132.3E	26.5N	131.8E	000-0030	29.9N	130.6E	042-0126	-----	------	--------
14	26/1100Z	23.7N	132.1E	23.5N	132.2E	27.3N	131.4E	010-0036	30.7N	130.2E	039-0144	35.8N	130.4E	031-0354
15	26/1700Z	24.2N	132.1E	24.3N	132.2E	27.2N	131.4E	104-0048	30.6N	130.3E	059-0144	-----	------	--------
16	26/2300Z	25.3N	132.2E	25.2N	132.2E	28.5N	132.0E	070-0120	31.6N	132.0E	063-0258	36.5N	132.8E	053-0402
17	27/0500Z	26.3N	132.0E	26.0N	131.8E	29.9N	131.7E	056-0168	33.5N	131.8E	051-0306	-----	------	--------
18	27/1100Z	27.0N	131.3E	26.7N	131.3E	30.4N	130.2E	044-0126	34.4N	130.0E	037-0270	39.9N	133.1E	047-0486
19	27/1700Z	27.6N	130.3E	27.4N	130.5E	30.5N	128.1E	010-0072	34.4N	128.9E	035-0210	-----	------	--------
20	27/2300Z	28.0N	129.7E	27.8N	129.8E	31.5N	127.8E	009-0114	36.1N	129.1E	032-0258	41.8N	135.0E	055-0576
21	28/0500Z	28.2N	128.9E	28.3N	129.0E	30.9N	127.4E	016-0042	35.5N	129.5E	052-0210	-----	------	--------
22	28/1100Z	28.9N	128.4E	28.8N	128.4E	31.7N	127.3E	022-0060	35.3N	127.7E	058-0108	40.6N	131.3E	064-0294
23	28/1700Z	29.4N	127.6E	29.3N	127.8E	32.5N	126.3E	354-0060	36.7N	127.5E	051-0138	-----	------	--------
24	28/2300Z	29.7N	127.4E	29.6N	127.4E	32.2N	126.3E	180-0012	36.1N	127.2E	093-0102	41.0N	131.8E	--------
25	29/0500Z	30.2N	127.1E	30.2N	127.1E	32.7N	126.2E	170-0036	36.6N	127.5E	106-0120	-----	------	--------
26	29/1100Z	30.8N	126.8E	30.7N	126.8E	33.9N	126.3E	128-0086	37.7N	127.9E	110-0120	42.1N	130.9E	--------
27	29/1700Z	31.6N	126.7E	31.5N	126.5E	35.0N	126.9E	098-0078	38.6N	128.0E	--------	-----	------	--------
28	29/2300Z	32.6N	126.4E	32.4N	126.3E	36.8N	128.1E	077-0150	42.3N	130.9E	--------	-----	------	--------
29	30/0500Z	33.2N	126.3E	33.3N	126.1E	36.9N	127.5E	098-0120	41.5N	130.1E	--------	-----	------	--------
30	30/1100Z	34.5N	126.0E	34.3N	125.7E	38.9N	127.3E	071-0034	-----	------	--------	-----	------	--------
31	30/1700Z	35.7N	126.1E	35.2N	125.3E	40.2N	128.2E	--------	-----	------	--------	-----	------	--------
32	30/2300Z	36.2N	125.1E	36.2N	125.0E	-----	------	--------	-----	------	--------	-----	------	--------
33	31/0500Z	37.2N	125.0E	37.2N	125.0E	-----	------	--------	-----	------	--------	-----	------	--------
34	31/1100Z	38.4N	125.6E	38.4N	125.5E	-----	------	--------	-----	------	--------	-----	------	--------

AVERAGE 24 HOUR ERROR - 0085 MI.
AVERAGE 48 HOUR ERROR - 0169 MI.
AVERAGE 72 HOUR ERROR - 0315 MI.

F. TYPHOON CLARA   26 AUG 0500Z-03 SEP 1100Z

1. STATISTICS

   a. Number of Warning Issued - 34

   b. Number of Warnings with Typhoon Intensity - 13

   c. Distance Traveled During Warning Period - 2,449 MI

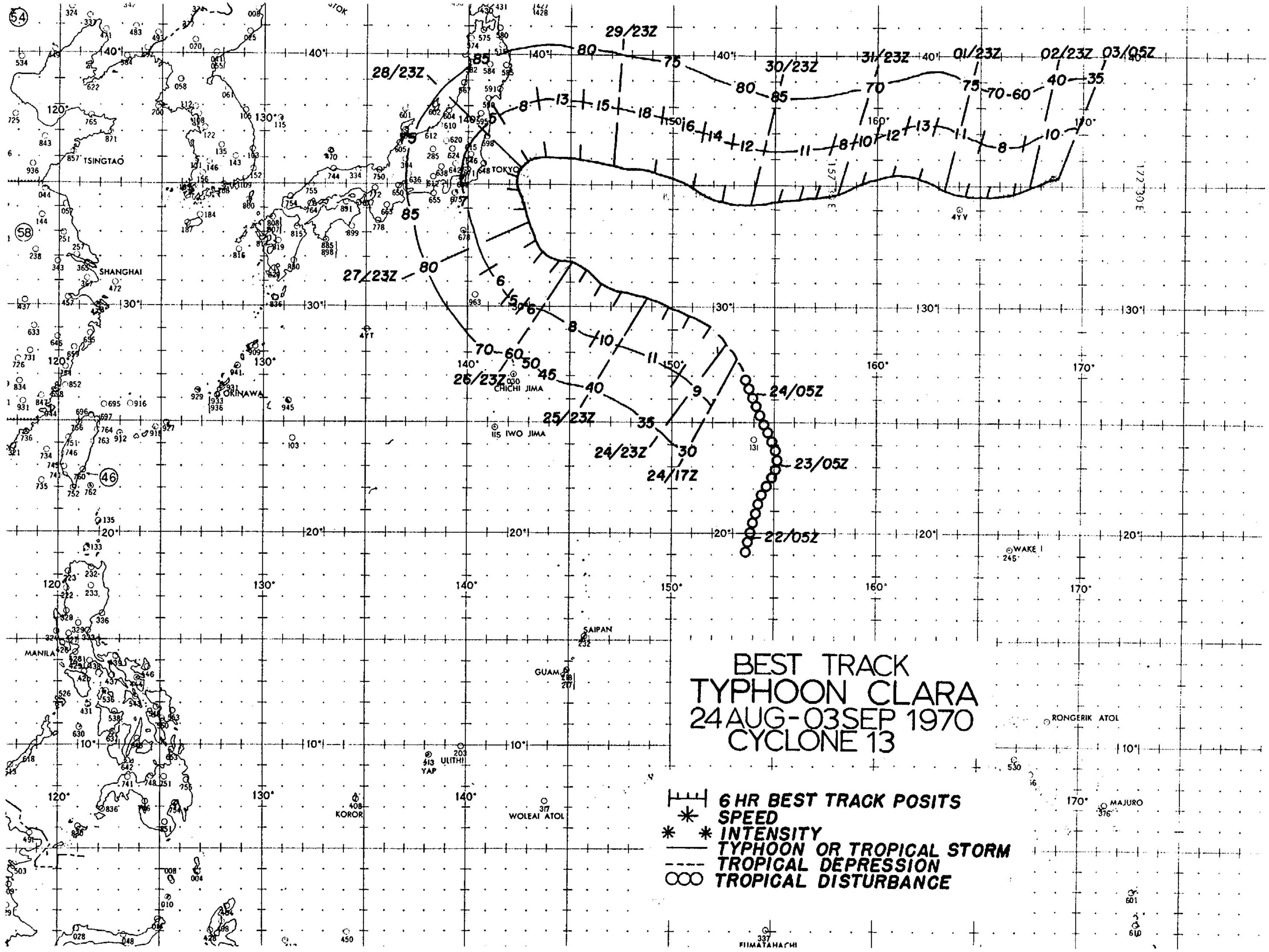
2. CHARACTERISTICS AS A TYPHOON

   a. Minimum Observed SLP - 965 MBS at 30/2100Z

   b. Minimum Observed 700 MB Height - 2789 M at 30/2100Z

   c. Maximum Surface Wind - 85 KTS (From Best Track)

   d. Maximum Radius of Surface Circulation - 420 MI


BEST TRACK
TYPHOON CLARA
24AUG-03SEP 1970
CYCLONE 13
6 HR BEST TRACK POSITS
SPEED
INTENSITY
TYPHOON OR TROPICAL STORM
TROPICAL DEPRESSION
TROPICAL DISTURBANCE
22/05Z
23/05Z
24/05Z
24/17Z
24/23Z
25/23Z
26/23Z
27/23Z
28/23Z
29/23Z
30/23Z
31/23Z
01/23Z
02/23Z
03/05Z
TOKYO
TSINGTAO
SHANGHAI
OKINAWA
CHICHI JIMA
IWO JIMA
MANILA
SAIPAN
GUAM
YAP
ULITHI
KOROR
WOLEAI ATOL
WAKE I
RONGERIK ATOL
MAJURO

3. TYPHOON CLARA NARRATIVE

The fourth typhoon of August appeared on the scene in its early stages as Billie was churning the waters of the Philippine Sea east of Okinawa. Clara developed to typhoon force at an unusually high latitude of 32°N. This was the 5th storm on record to reach typhoon intensity north of the 30th parallel since 1945.

The pre-Clara system was first noted by the ITOS-1 satellite on the 21st south of Marcus Island. The disturbance was related to an upper tropospheric circulation which had separated from the Mid-Pacific trough. The system drifted in a generally northward direction for the next two days and gradually attained a warm core.

On passage of Marcus on the 24th, the island's sounding indicated warming greater than one degree at all levels from 850 to 300 mb. After passage of Marcus a weak surface circulation developed.

The depression, not more than a degree and a half in diameter, reacted to a blocking ridge line to its north by commencing a more westerly track at 9-11 knots.

During the period of the 25th to the 26th the Clara circulation passed under a 200 mb shear line which acted as a hostile environment for further development as mass outflow from the system was retarded. Thus Clara barely attained minimum tropical storm strength during this portion of her track.

Later on the 26th, the system moved from beneath the shear line aloft, slowly strengthened and reached typhoon force the following day although its circulation remained small. Clara shifted to a northeast course 300 miles southeast of Tokyo late on the 27th and came under surveillance of the radar atop Mount Fuji (See Figure 5-11).

The typhoon missed connections with a short wave in the westerlies passing to the north. It instead took a sharp turn to the east on the 29th 120 mi abeam of Tokyo (Figure 5-12) as flow to the rear of the trough forced the storm on an abrupt change of course. For the next five days, Clara was effectively cut off from the westerlies and maintained her typhoon intensity along a 1,200 mile sinusoidal path towards Ocean Station Victor.

Late on the 2nd, Clara began to turn to the northeast and weaken along the periphery of the westward extension of the subtropical high system centered near the Hawaiian Islands. As increasing vertical shear was encountered and drier and

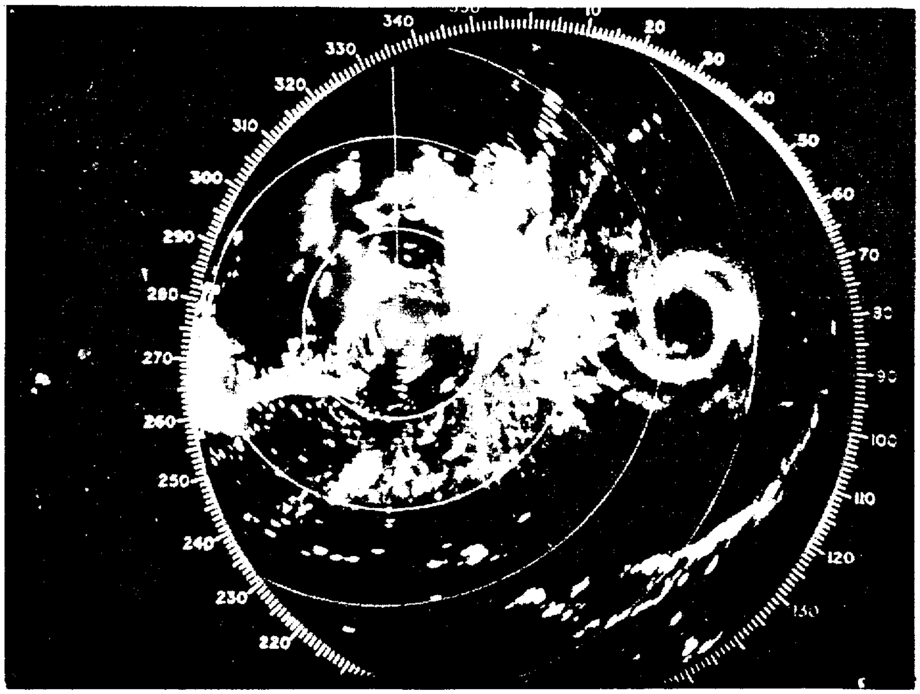


FIGURE 5-11 RADAR SCOPE PHOTOGRAPH OF TYPHOON CLARA AS VIEWED BY MT. FUJI MITSUBISHI RADAR (10.4 CM) ON 29 AUGUST AT 0417 GMT (COURTESY JAPAN METEROLOGICAL AGENCY, TOKYO DISTRICT OBSERVATORY). RANGE MARKS ARE AT 100 KM INTERVALS. MUCH OF THE ECHO RETURN OUTSIDE THE WALL CLOUD AREA IS DUE TO GROUND CLUTTER AND SEA RETURN.

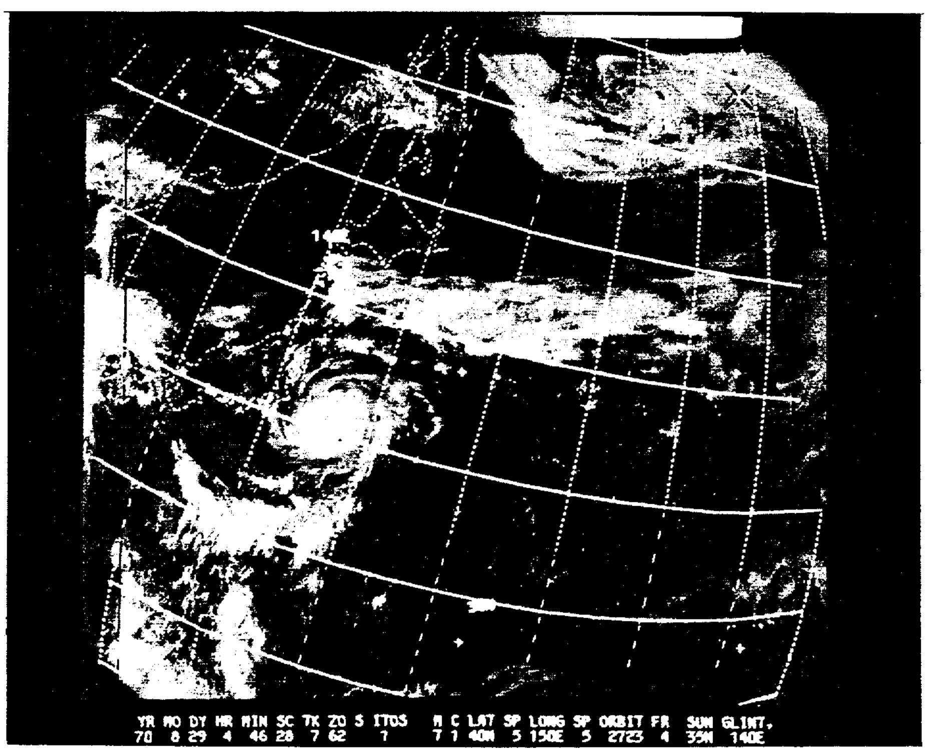


FIGURE 5-12 TYPHOON CLARA AS SEEN BY ITOS-1 ON 29 AUGUST DUE EAST OF TOKYO.

cooler air entrained into the circulation the storm gradually weakened until it was absorbed by a frontal system on the 4th.

During her eastward trek across the West Pacific, Clara affected numerous vessels in the shipping lanes. The Swedish vessel Sonette along with the Netherlands vessel Precent estimated winds of 80 knots on their close encounters with the storm respectively on the 30th of August and the 1st of September.

An interesting sidenote was that Hurricane Dot in the Central Pacific[1] formed on the 1st of September and was recurving close to the International Date Line on the 2nd and 3rd. Reconnaissance planes that were fixing Clara from Wake Island were called upon to position Dot before landing at Midway Island. An unusual accomplishment thus took place on the 3rd of September as reconnaissance aircraft fixed both a typhoon and a hurricane on the same mission.

---

[1]Dot was the forecast responsibility of the Central Pacific Hurricane Center, Honolulu.

TYPHOON CLARA

EYE FIXES CYCLONE 13

FIX NO.	TIME	POSIT	UNIT-METHOD-ACCY	FLT LVL	FLT LVL WND	OBS SFC WND	OBS MIN SLP	MIN 700MB HGT	FLT LVL TT/TD	EYE FORM	ORIEN-TATION	EYE DIA	CHARACTER WALL CLOUD
1	230449Z	23.0N 155.5E	SLTLS	STG C	DIA --	CAT -							----------
2	240350Z	26.0N 154.5E	SLTLS	STG C	DIA --	CAT -							----------
3	250447Z	29.0N 152.5E	SLTLS	STG X	DIA 02	CAT 2							----------
4	260543Z	30.5N 148.0E	SLTLS	STG X	DIA 02	CAT 2							----------
5	262100Z	31.9N 145.4E	54--05---	700MB	055	050	985	2908	12/07	CIRC	----	22	CLSD 12-15NM THK
6	270300Z	31.9N 144.6E	54--05---	700MB	055	070	976	2893	14/07	CIRC	----	15	OPEN NE QUAD
7	270449Z	31.0N 144.0E	SLTLS	STG C	DIA --	CAT -							----------
8	270950Z	31.8N 144.5E	VW---20---		---	---	---	---	--/--	----			----------
9	271000Z	32.8N 142.8E	LND RDR		---	---	---	---	--/--	----			----------
10	271055Z	32.0N 143.9E	VW---10---		---	---	---	---	--/--	----			CLSD 9-27NM THK
11	271440Z	32.6N 143.6E	VW---05---		045	---	---	---	--/--	CIRC	----	09	CLSD
12	271500Z	32.5N 143.6E	LND RDR		---	---	---	---	--/--	----			----------
13	271700Z	32.8N 143.5E	LND RDR		---	---	---	---	--/--	----			----------
14	271800Z	32.8N 143.4E	LND RDR		---	---	---	---	--/--	----			----------
15	271900Z	33.0N 143.4E	LND RDR		---	---	---	---	--/--	----			----------
16	272100Z	33.1N 143.2E	54--05---	700MB	065	080	971	2850	15/08	CIRC	----	10	5NM THK, OPEN SE-S
17	272300Z	33.1N 143.2E	LND RDR		---	---	---	---	--/--	----			----------
18	280041Z	33.2N 143.0E	54--05---	700MB	055	085	969	2853	14/07	CIRC	----	19	OPEN SE-S-W
19	280300Z	33.8N 142.9E	54--05---	700MB	057	085	968	2865	17/07	CIRC	----	20	OPEN SE-SW
20	280500Z	33.9N 142.8E	LND RDR		---	---	---	---	--/--	----			----------
21	280545Z	33.0N 142.5E	SLTLS	STG C	DIA --	CAT -							----------
22	280600Z	34.0N 142.8E	LND RDR		---	---	---	---	--/--	----			----------
23	280700Z	34.2N 142.7E	LND RDR		---	---	---	---	--/--	----			----------
24	280830Z	34.4N 142.5E	VW---05---		---	---	---	---	--/--	CIRC	----	35	OPEN S
25	280900Z	34.3N 142.7E	LND RDR		---	---	---	---	--/--	----			----------
26	281100Z	34.5N 142.5E	LND RDR		---	---	---	---	--/--	----			----------
27	281200Z	34.8N 142.5E	LND RDR		---	---	---	---	--/--	----			----------
28	281401Z	34.9N 142.5E	VW---10---	700MB	005	---	978	2975	16/09	CIRC	----	25	OPEN S QUAD
29	281500Z	35.0N 142.2E	LND RDR		---	---	---	---	--/--	----			----------
30	281600Z	35.1N 142.2E	LND RDR		---	---	---	---	--/--	----			----------
31	281700Z	35.3N 142.3E	LND RDR		---	---	---	---	--/--	----			----------
32	281800Z	35.3N 142.1E	LND RDR		---	---	---	---	--/--	----			----------
33	282000Z	35.5N 142.2E	LND RDR		---	---	---	---	--/--	----			----------
34	282100Z	35.6N 142.2E	54--05---	700MB	075	075	973	2862	15/08	CIRC	----	35	CLSD
35	282100Z	35.7N 142.2E	LND RDR		---	---	---	---	--/--	----			----------
36	282100Z	35.5N 142.3E	LND RDR		---	---	---	---	--/--	----			----------
37	282200Z	35.6N 142.4E	LND RDR		---	---	---	---	--/--	----			----------
38	282300Z	35.6N 142.4E	LND RDR		---	---	---	---	--/--	----			----------
39	290000Z	35.6N 142.5E	LND RDR		---	---	---	---	--/--	----			----------
40	290100Z	35.6N 142.6E	LND RDR		---	---	---	---	--/--	----			----------
41	290200Z	35.6N 142.8E	LND RDR		---	---	---	---	--/--	----			----------
42	290300Z	35.9N 142.7E	54--05---	700MB	065	120	975	2841	17/14	CIRC	----	20	OPEN SSW
43	290446Z	35.8N 142.5E	SLTLS	STG X	DIA 0[illegible]	CAT 3							----------
44	290600Z	36.1N 143.0E	LND RDR		---	---	---	---	--/--	----			----------
45	290600Z	35.8N 143.2E	LND RDR		---	---	---	---	--/--	----			----------
46	290854Z	36.1N 143.4E	VW---05---		---	100	977	---	--/28	CIRC	----	28	OPEN W
47	291200Z	35.0N 144.4E	LND RDR		---	---	---	---	--/--	----			----------
48	291420Z	36.1N 144.3E	VW---08---		---	100	985	2990	--/--	CIRC	----	20	OPEN W

TYPHOON CLARA

EYE FIXES CYCLONE 13

FIX NO.	TIME	POSIT	UNIT-METHOD-ACCY	FLT LVL	FLT LVL WND	OBS SFC WND	OBS MIN SLP	MIN 700MB HGT	FLT LVL TT/TD	EYE FORM	ORIEN-TATION	EYE DIA	CHARACTER WALL CLOUD
49	292115Z	36.0N 146.9E	54---05---	700MB	072	050	975	2883	15/14	ELIP	NW-SE	25X18	CLSD
50	300000Z	35.6N 147.6E	54---05---	700MB	073	080	974	2868	16/12	ELIP	NW-SE	12X--	CLSD, APRS BRKG UP
51	300215Z	35.6N 148.3E	54---08---	700MB	070	060	969	2832	16/11	ELIP	NW-SE	28X22	OPEN NW, BRKG UP
52	300543Z	34.5N 150.5E	SLTS	STG X	DIA 03	CAT 3							----------
53	300926Z	35.6N 151.2E	VW---02---	3080M	068	---	983	2929	17/12	ELIP	NW-SE	38X28	OPEN W
54	301405Z	34.6N 151.9E	VW---10---	3000M	065	---	973	2911	16/10	CIRC	----	30	OPEN NE-SW, BRKG UP NE
55	302100Z	34.3N 153.4E	54---05---	700MB	060	085	965	2789	13/08	CIRC	----	30	CLSD
56	310250Z	34.2N 154.7E	54---05---	700MB	060	090	960	2800	18/07	CIRC	----	30	CLSD, ILL DEF S QUAD
57	310444Z	34.5N 155.0E	SLTS	STG X	DIA 03	CAT 2							----------
58	310915Z	34.5N 156.1E	VW---05---	3000M	070	060	973	2853	13/18	CIRC	----	28	CLSD, 15NM THK N SEMICIR
59	311130Z	34.7N 156.6E	VW---10---	3000M	045	---	---	---	--/--	CIRC	----	28	CLSD
60	010300Z	35.0N 158.0E	54---30---	700MB	060	100	975	2893	17/10	CIRC	----	15	NOT WELL DEF, OPEN S
61	010405Z	35.0N 158.5E	SLTS	STG X	DIA 02	CAT 2							----------
62	011004Z	35.6N 160.3E	VW---20---		---	---	---	---	--/--	----			----------
63	011147Z	35.4N 160.9E	VW---05---	700MB	065	---	979	2963	16/12	CIRC	----	15	CLSD
64	011230Z	35.5N 161.3E	VW---20---		---	---	---	---	--/--	----			----------
65	012056Z	35.1N 163.1E	54---15---	700MB	052	085	983	2935	18/10	CIRC	----	30	OPEN SSW-NNE
66	020300Z	34.8N 163.7E	54---20---	700MB	060	090	979	2941	17/12	CIRC	----	15	OPEN NE
67	020440Z	34.0N 165.0E	SLTS	SIG X	DIA 02	CAT 2							----------
68	021230Z	34.7N 165.1E	VW--------		---	---	---	---	--/--	----			W/C S SEMICIR,6NM THK
69	021250Z	34.6N 165.4E	VW---05---		---	045	991	---	24/24	----			----------
70	022015Z	34.9N 166.9E	54---15---	700MB	039	040	992	3021	15/--	----			NEG W/C
71	030340Z	34.0N 168.0E	SLTS	STG C	DIA --	CAT -							----------
72	030400Z	35.2N 168.4E	54---10---	700MB	035	030	993	3030	11/09	----			NEG W/C
73	040242Z	38.0N 160.0E	SLTS	SIG C	DIA --	CAT -							----------

TYPHOON CLARA

TROPICAL CYCLONE 13 -- 8/24/1700Z TO 9/3/0500Z
POSITION AND FORECAST VERIFICATION DATA

WARN NO.	DTG	WARNING POSIT LAT	WARNING POSIT LONG	BEST TRACK LAT	BEST TRACK LONG	24 HR FCST LAT	24 HR FCST LONG	24 HR ERROR DEG DIST	48 HR FCST LAT	48 HR FCST LONG	48 HR ERROR DEG DIST	72 HR FCST LAT	72 HR FCST LONG	72 HR ERROR DEG DIST
01	26/0500Z	30.5N	147.5E	30.6N	147.5E	31.7N	142.1E	264-0108	-----	------	--------	-----	------	--------
02	26/1100Z	30.8N	146.3E	31.0N	146.6E	32.0N	140.6E	266-0162	-----	------	--------	-----	------	--------
03	26/1700Z	31.0N	145.3E	31.5N	145.9E	32.1N	140.3E	258-0156	-----	------	--------	-----	------	--------
04	26/2300Z	32.0N	145.1E	31.9N	145.0E	34.1N	141.6E	298-0072	36.8N	139.6E	296-0144	42.7N	144.6E	345-0432
05	27/0500Z	32.0N	144.3E	31.9N	144.3E	33.8N	138.4E	266-0216	-----	------	--------	-----	------	--------
06	27/1100Z	32.0N	143.9E	32.2N	143.8E	33.8N	138.5E	255-0198	-----	------	--------	-----	------	--------
07	27/1700Z	32.8N	143.5E	32.7N	143.4E	35.7N	142.0E	338-0030	39.7N	142.4E	327-0252	-----	------	--------
08	27/2300Z	33.1N	143.1E	33.5N	143.0E	35.8N	141.9E	284-0024	40.0N	145.0E	340-0270	-----	------	--------
09	28/0500Z	34.0N	142.8E	34.1N	142.7E	36.2N	141.8E	284-0048	-----	------	--------	-----	------	--------
10	28/1100Z	34.6N	142.4E	34.7N	142.4E	37.4N	141.8E	306-0120	-----	------	--------	-----	------	--------
11	28/1700Z	35.3N	142.3E	35.2N	142.3E	38.1N	142.8E	314-0168	-----	------	--------	-----	------	--------
12	28/2300Z	35.8N	142.2E	35.7N	142.4E	38.5N	143.1E	312-0246	-----	------	--------	-----	------	--------
13	29/0500Z	36.0N	142.9E	36.0N	142.8E	37.6N	146.6E	314-0174	-----	------	--------	-----	------	--------
14	29/1100Z	36.3N	143.8E	36.2N	143.8E	37.4N	147.9E	313-0216	-----	------	--------	-----	------	--------
15	29/1700Z	36.3N	144.8E	36.1N	145.4E	36.7N	149.1E	310-0210	37.0N	155.0E	324-0174	-----	------	--------
16	29/2300Z	35.8N	147.2E	35.7N	147.0E	35.4N	156.1E	060-0126	-----	------	--------	-----	------	--------
17	30/0500Z	35.6N	149.4E	35.5N	149.2E	39.4N	157.9E	024-0330	-----	------	--------	-----	------	--------
18	30/1100Z	35.6N	151.8E	34.9N	151.1E	36.9N	159.7E	049-0222	-----	------	--------	-----	------	--------
19	30/1700Z	34.6N	152.8E	34.4N	152.4E	36.0N	158.4E	036-0102	-----	------	--------	-----	------	--------
20	30/2300Z	34.3N	153.9E	34.3N	153.8E	35.7N	159.7E	058-0096	-----	------	--------	-----	------	--------
21	31/0500Z	34.2N	155.2E	34.3N	155.1E	34.7N	160.8E	112-0078	-----	------	--------	-----	------	--------
22	31/1100Z	36.2N	156.5E	34.4N	156.2E	36.2N	162.3E	059-0090	-----	------	--------	-----	------	--------
23	31/1700Z	34.8N	157.9E	34.6N	157.1E	36.7N	163.7E	043-0114	-----	------	--------	-----	------	--------
24	31/2300Z	34.9N	157.8E	34.8N	158.0E	35.6N	159.5E	282-0186	37.2N	161.7E	295-0300	-----	------	--------
25	01/0500Z	35.0N	158.1E	35.2N	159.3E	35.9N	159.9E	288-0222	37.6N	162.2E	293-0352	-----	------	--------
26	01/1100Z	35.4N	160.7E	35.4N	160.7E	38.6N	165.8E	000-0234	-----	------	--------	-----	------	--------
27	01/1700Z	35.9N	161.9E	35.3N	162.0E	39.6N	167.0E	006-0288	-----	------	--------	-----	------	--------
28	01/2300Z	35.1N	163.8E	34.9N	163.3E	35.8N	170.5E	072-0150	38.3N	178.2E	--------	-----	------	--------
29	02/0500Z	34.8N	164.0E	34.7N	164.3E	34.4N	167.8E	222-0075	35.6N	173.4E	--------	-----	------	--------
30	02/1100Z	34.5N	165.2E	34.7N	165.8E	34.7N	169.6E	--------	36.4N	175.4E	--------	-----	------	--------
31	02/1700Z	34.8N	166.3E	34.8N	166.3E	36.2N	171.1E	--------	-----	------	--------	-----	------	--------
32	02/2300Z	35.0N	167.3E	35.0N	167.5E	-----	------	--------	-----	------	--------	-----	------	--------
33	03/0500Z	35.3N	168.5E	35.4N	168.8E	-----	------	--------	-----	------	--------	-----	------	--------
34	03/1100Z	35.4N	169.8E	-----	------	-----	------	--------	-----	------	--------	-----	------	--------

AVERAGE 24 HOUR ERROR - 0153 MI.
AVERAGE 48 HOUR ERROR - 0249 MI.
AVERAGE 72 HOUR ERROR - 0432 MI.

G. TYPHOON GEORGIA 07 SEP 2300Z-14 SEP 2300Z

1. STATISTICS

   a. Number of Warnings Issued - 26

   b. Number of Warnings with Typhoon Intensity - 19

   c. Distance Traveled During Warning Period - 1,718 MI

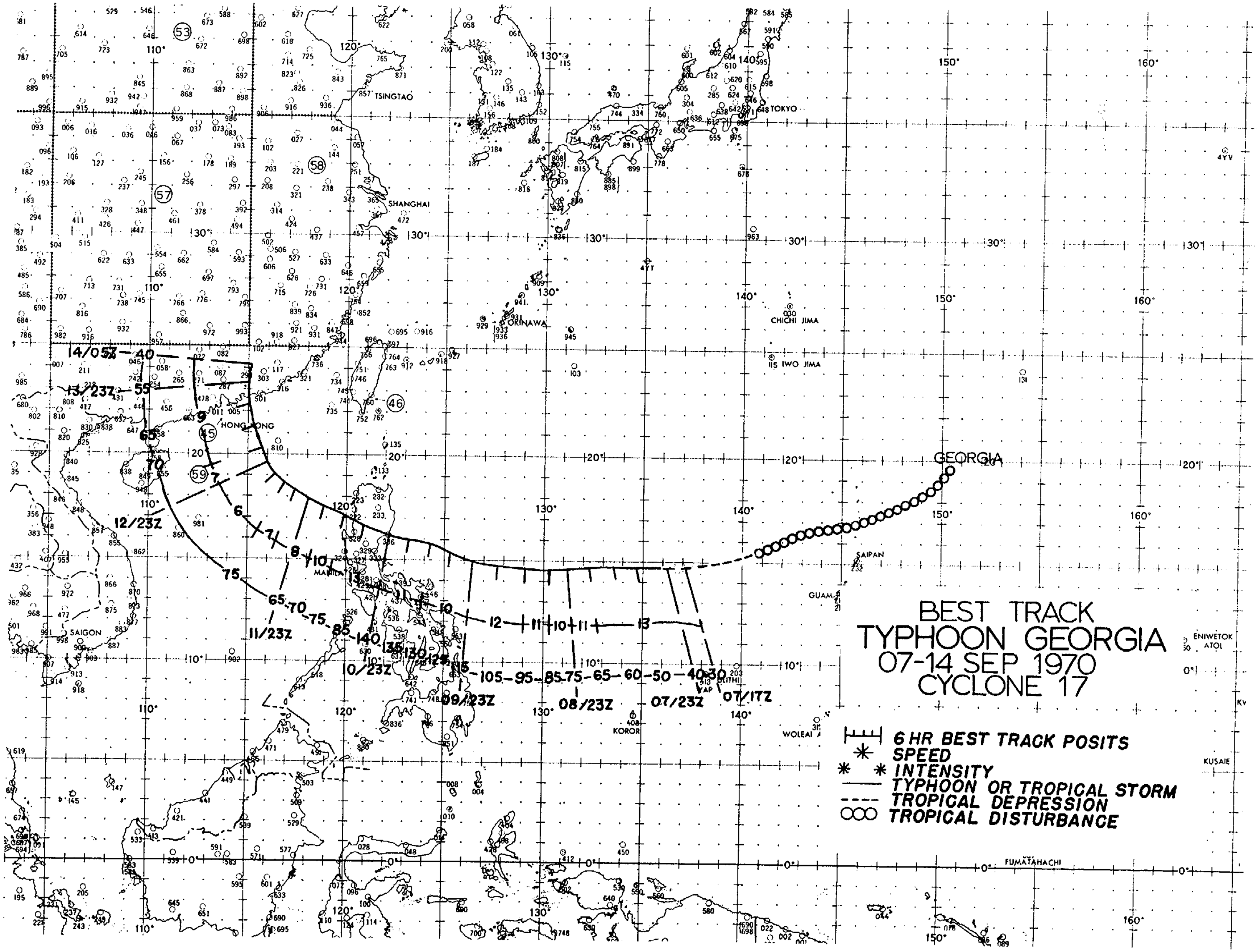
2. CHARACTERISTICS

   a. Minimum Observed SLP - 904 MBS at 10/2040Z

   b. Minimum Observed 700 MB Height - 2390 M at 10/0600Z

   c. Maximum Surface Wind - 140 KTS (From Best Track)

   d. Maximum Radius of Surface Circulation - 360 MI


BEST TRACK
TYPHOON GEORGIA
07-14 SEP 1970
CYCLONE 17
6 HR BEST TRACK POSITS
SPEED
INTENSITY
TYPHOON OR TROPICAL STORM
TROPICAL DEPRESSION
TROPICAL DISTURBANCE
GEORGIA
HONG KONG
MANILA
SHANGHAI
TSINGTAO
TOKYO
OKINAWA
CHICHI JIMA
IWO JIMA
SAIPAN
GUAM
KOROR
YAP
WOLEAI
SAIGON
ENIWETOK ATOL
KUSAIE
FUMATAHACHI
07/17Z
07/23Z
08/23Z
09/23Z
10/23Z
11/23Z
12/23Z
13/23Z
14/05Z

3. TYPHOON GEORGIA NARRATIVE

An ITOS-1 photograph on the 4th indicated that an upper tropospheric circulation in existence west of Marcus Island had developed a significant increase in convective activity along its southern periphery. The disturbance drifted southwestward toward the northern Marianas with an induced trough appearing on the 0000GMT surface chart on September 5th. The system continued on its southwestward track with a small surface circulation forming west of the Marianas a day later. An aerial reconnaissance investigation on the 8th revealed that tropical storm force had been reached and the first warning on Georgia was issued (Figure 5-13).

The storm began a westward march at 11 to 13 knots across the Philippine Sea as guided by the southern boundary of the subtropical ridge. Typhoon force was achieved early the next morning as difluent equatorward flow over the storm, from the 200 mb ridge extension south of Japan, favored further deepening.

Early on the 10th Georgia began to shift to a slightly more west northwest track, and that evening, as she neared the Luzon coastline, maximum winds occurring near the center reached super typhoon force near 140 knots. The ITOS-1 satellite showed a tightly organized ring of convective activity surrounding the storm near this time (Figure 5-14). This was further evidenced in the fact that Casiguran Weather Bureau Station on the Luzon coast, 90 miles from the center, had yet to experience gale force winds although the typhoon was only 6 hours from landfall. A reconnaissance aircraft in the 10 mile diameter eye of Georgia, a few hours before she struck shore, recorded an extremely warm 500 mb temperature of 14.5°C and indicated the deepening trend had reached 904 mb.

The typhoon slammed into North Central Luzon during the early morning hours of the 11th near Cape San Ildefonso. Extensive damage was suffered at Casiguran, which was 15 N.M. north of the center at landfall, and several surrounding small villages along the coastline. Minimum pressure at Casiguran was reported at 977.5 mb with winds estimated at 120 knots. By contrast the storm did not produce excessive torrential rains but was relatively dry with only 5.44 inches recorded during its passage at the weather station. Ninety-five persons were killed during the onslaught and an additional 80 people reported missing. Property damage was fixed near 1.4 million dollars.

The storm continued on a west northwest track across Luzon and emerged into the South China Sea 12 hours later of minimum typhoon strength due to the disrupting mountainous terrain of the island. A weakness in the ridgeline over China

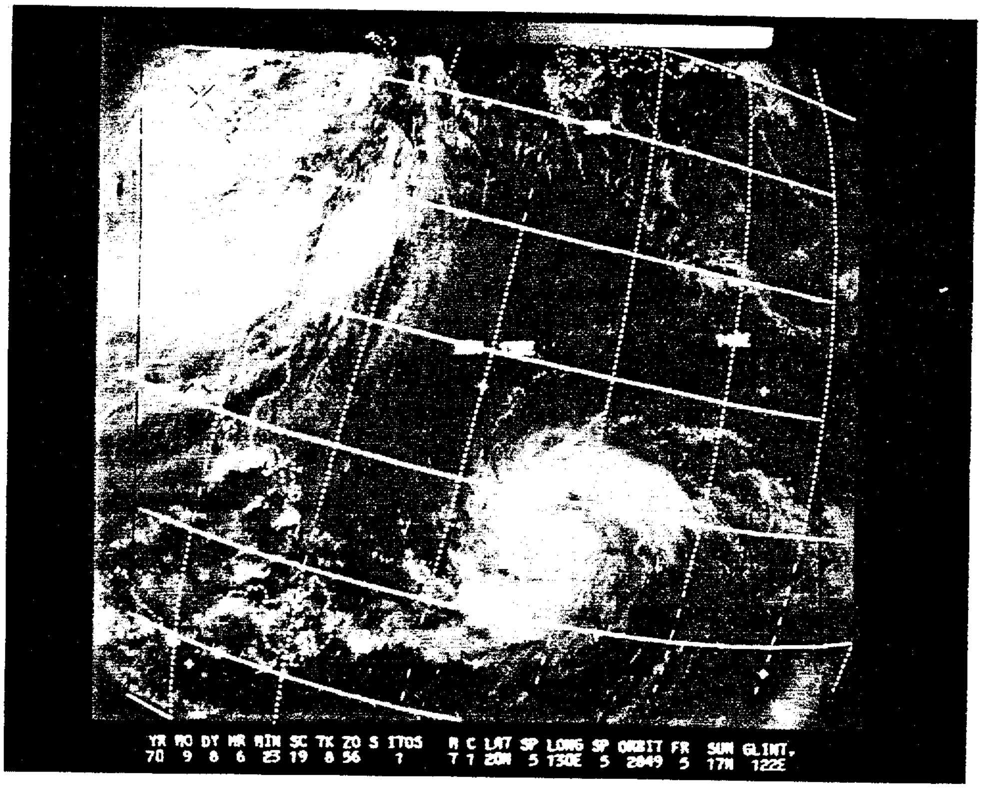


FIGURE 5-13 ITOS-1 PHOTO OF GEORGIA AS A DEVELOPING TROPICAL STORM ON 8 SEPTEMBER.

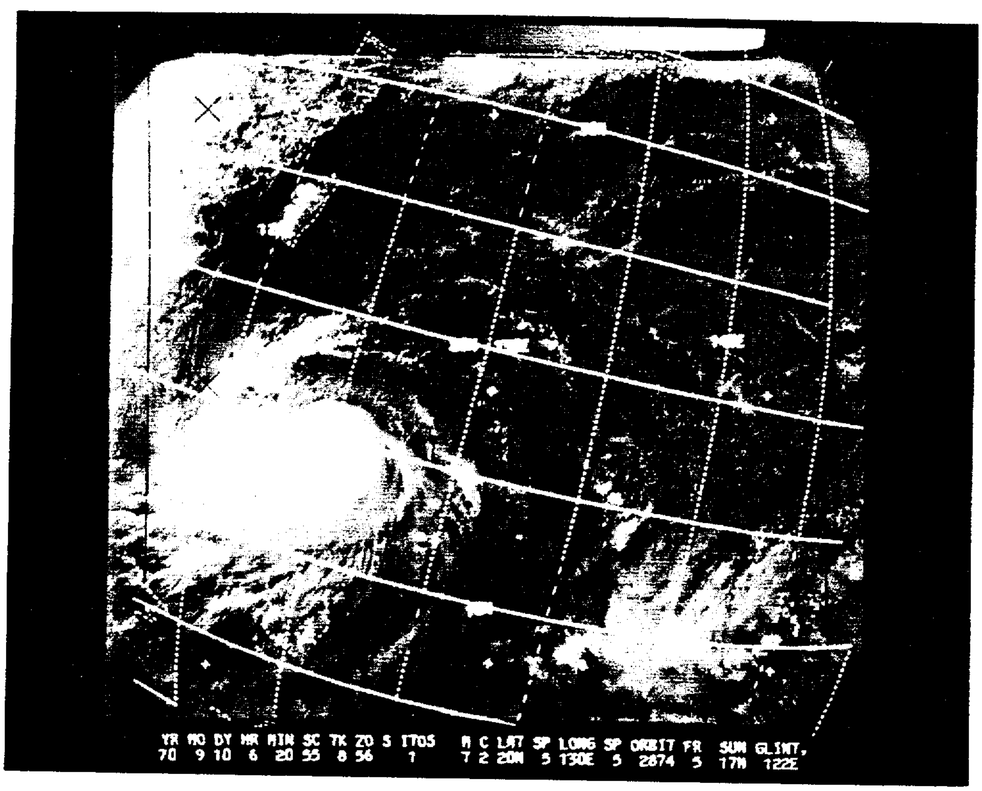


FIGURE 5-14 SUPER TYPHOON GEORGIA AS VIEWED BY ITOS-1 ON 10 SEPTEMBER JUST EAST OF LUZON.

provided a path for Georgia to recurve on a northward course with ultimate landfall occurring some 70 miles east of Hong Kong on the 14th.

The storm's intensity remained near 70 to 75 knots during its trek across the South China Sea while its eye was noted by reconnaissance crews to have expanded to some 70 miles in diameter.

By the 13th the storm came under surveillance of the radar at the Royal Observatory at Hong Kong and was later observed to cross the South China coast the following morning. Maximum gusts of 59 knots occurred at the Hong Kong International Airport while peak gusts of 56 knots were registered at the Royal Observatory. Georgia weakened rapidly after landfall and dissipated over land.

TYPHOON GEORGIA

EYE FIXES CYCLONE 17

FIX NO.	TIME	POSIT	UNIT-METHOD-ACCY	FLT LVL	FLT LVL WND	OBS SFC WND	OBS MIN SLP	MIN 700MB HGT	FLT LVL TT/TD	EYE FORM	ORIEN-TATION	EYE DIA	CHARACTER WALL CLOUD
1	070526Z	14.0N 139. E	SLTLS	STG 3	DIA --	CAT -							----------
2	080130Z	14.7N 135.6E	54-P-05---	700MB	030	040	000	3057	11/09	CIRC	----	--	W/C N-SE
3	080330Z	14.6N 135.1E	54-P-05---	700MB	040	025	995	3057	13/08	CIRC	----	--	W/C N-SE
4	080623Z	14.5N 135.0E	SLTLS	STG C	DIA --	CAT -							----------
5	081015Z	14.7N 133.9E	VW-P-03---	700MB	042	---	000	3066	14/09	----			W/C NW-S
6	081402Z	14.8N 132.9E	VW-P-05---	700MB	055	---	993	3039	16/09	ELIP	N-S	--X--	5-7NM THK, OPEN E-W
7	082100Z	14.7N 131.5E	54-P-20---	700MB	060	---	983	2978	14/10	CIRC	----	24	CLSD, SML BRKS N QUAD
8	090300Z	14.3N 130.7E	54-P-10---	700MB	070	090	975	2908	16/09	CIRC	----	14	CLSD 4NM THK
9	090715Z	14.5N 130.0E	SLTLS	STG X	DIA 07	CAT 2							----------
10	091335Z	14.0N 128.6E	VW--------		---	---	---	---	--/--	----			----------
11	091438Z	14.7N 128.1E	VW-P-05---		---	080	---	---	--/24	CIRC	----	19	4NM THK, OPEN NW QUAD
12	091535Z	14.7N 127.8E	VW-P-05---	700MB	---	---	976	2728	21/13	CIRC	----	18	3NM THK, OPEN N QUAD
13	092100Z	14.8N 126.7E	54-P-03---	700MB	10	110	937	2554	22/09	CIRC	----	16	CLSD 3NM THK
14	100000Z	15.2N 126.4E	LND RDR		---	---	---	---	--/--	----			----------
15	100105Z	14.8N 126.2E	ACFT RDR	300MB	---	---	---	---	--/--	CONC		40-20	OUTER-CLSD, INNER-CLSD
16	100300Z	15.2N 125.5E	54-P-05---	700MB	080	130	927	2451	19/09	CIRC	----	14	CLSD 3NM THK
17	100600Z	15.2N 125.2E	54-P-05---	700MB	095	130	920	2390	17/11	CIRC	----	12	CLSD 3NM THK
18	100621Z	15.0N 124.5E	SLTLS	STG X	DIA 03	CAT 4							----------
19	100830Z	15.5N 124.5E	LND RDR		---	---	---	---	--/--	----			----------
20	100906Z	15.6N 124.6E	54-P-05---	400MB	---	---	---	---	--/--	CIRC	----	15	CLSD 3NM THK
21	100908Z	15.5N 124.6E	VW- -10---		050	085	---	---	--/--	CIRC	----	12	CLSD 4NM THK
22	101030Z	15.7N 124. E	LND RDR		---	---	---	---	--/--	----			----------
23	101110Z	15.6N 124.2E	LND RDR		---	---	---	---	--/--	----			----------
24	101200Z	15.5N 124.3E	VW- -10---		045	---	---	---	--/--	CIRC	----	12	CLSD 4NM THK
25	101230Z	15.7N 124.2E	LND RDR		---	---	---	---	--/--	----			----------
26	101530Z	15.8N 123.4E	LND RDR		---	---	---	---	--/--	----			----------
27	101600Z	15.8N 123.3E	LND RDR		---	---	---	---	--/--	----			----------
28	101630Z	15.9N 123.3E	VW-P-02---		---	---	---	---	--/--	CIRC	----	12	CLSD 4NM THK
29	101725Z	15.9N 123.1E	VW-P-03---		---	---	---	---	--/--	CIRC	----	12	CLSD
30	101730Z	16.0N 123.0E	LND RDR		---	---	---	---	--/--	----			----------
31	101830Z	16.0N 122.8E	LND RDR		---	---	---	---	--/--	----			----------
32	101900Z	16.0N 122.7E	LND RDR		---	---	---	---	--/--	----			----------
33	102000Z	16.0N 122.6E	LND RDR		---	---	---	---	--/--	----			----------
34	102040Z	15.9N 122.4E	54-P-03---	500MB	080	---	---	---	15/01	CIRC	----	10	CLSD
35	110245Z	16.6N 121.3E	54-P-10---	500MB	---	---	---	---	--/--	CIRC		5	CLSD ON RDR
36	110717Z	17.5N 120.0E	SLTLS	STG X	DIA 05	CAT 2							----------
37	110930Z	17.3N 119.9E	VW-P-25---		---	055	---	---	--/--	----			NEG WALL
38	111400Z	17.6N 119.1E	VW-P-20---		---	060	---	---	--/--	----			ILL DEFINED
39	112100Z	17.5N 117.8E	54-P-05---	700MB	055	---	984	2984	15/13	CIRC	----	25	CLSD
40	120100Z	18.0N 117.8E	54-P-05---	700MB	065	040	983	2957	15/13	----			NEG W/C
41	120619Z	18.0N 116.5E	SLTLS	STG X	DIA 05	CAT 3							----------
42	120910Z	18.5N 117.1E	VW-P-03---		---	080	975	---	26/23	CIRC	----	75	NEG W/C
43	121515Z	19.3N 116.3E	VW-P-06---		080	---	982	2969	23/18	ELIP	NW-SE	85X70	NEG W/C
44	122110Z	19.8N 116.1E	54-P-05---	700MB	065	---	973	2890	18/13	CIRC	----	45	OPEN S
45	130010Z	19.6N 116.0E	54-P-05---	700MB	065	060	974	2887	17/12	CIRC	----	40	OPEN NE 8NM THK
46	130248Z	20.0N 115.9E	54-P-05---	700MB	085	050	974	2987	17/12	CIRC	----	60	CENTER OPEN NE
47	130715Z	20.5N 115.5E	SLTLS	STG X	DIA 0	CAT 2							----------
48	130905Z	20.7N 115.5E	VW-P-15---		05	55	---	---	--/--	ELIP	NW-SE	99X58	CENTER OPEN NW
49	131200Z	21.5N 115.7E	VW--------		---	---	---	---	--/--	----			----------

TYPHOON GEORGIA

TROPICAL CYCLONE 17 -- 9/7/1700Z TO 9/14/0500Z
POSITION AND FORECAST VERIFICATION DATA

WARN NO.	DTG	WARNING POSIT		BEST TRACK		24 HR FCST		24 HR ERROR	48 HR FCST		48 HR ERROR	72 HR FCST		72 HR ERROR
		LAT	LONG	LAT	LONG	LAT	LONG	DEG DIST	LAT	LONG	DEG DIST	LAT	LONG	DEG DIST
01	07/2300Z	14.5N	136.0E	14.6N	136.1E	15.7N	132.9E	054-0120	-----	------	--------	-----	------	--------
02	08/0500Z	14.7N	134.9E	14.6N	134.8E	15.8N	131.0E	027-0090	17.5N	128.2E	049-0204	-----	------	--------
03	08/1100Z	14.7N	133.7E	14.6N	133.6E	14.9N	129.3E	027-0024	16.4N	125.5E	051-0084	18.8N	122.2E	051-0168
04	08/1700Z	14.7N	132.2E	14.7N	132.3E	15.4N	127.6E	360-0042	17.3N	124.0E	026-0096	-----	------	--------
05	08/2300Z	14.7N	131.1E	14.5N	131.2E	15.2N	126.3E	360-0018	16.8N	122.5E	021-0048	19.2N	119.2E	036-0102
06	09/0500Z	14.4N	130.3E	14.4N	130.2E	14.5N	126.0E	144-0048	15.8N	122.1E	126-0078	-----	------	--------
07	09/1100Z	14.3N	129.3E	14.5N	129.0E	14.6N	125.4E	131-0078	15.7N	121.8E	124-0138	17.1N	118.3E	138-0126
08	09/1700Z	14.7N	127.6E	14.7N	127.7E	15.2N	123.3E	170-0036	16.4N	119.9E	134-0084	-----	------	--------
09	09/2300Z	14.8N	126.3E	14.9N	126.4E	15.7N	121.7E	226-0024	17.4N	118.0E	180-0024	20.0N	114.8E	289-0066
10	10/0500Z	15.2N	125.1E	15.2N	125.4E	17.5N	120.9E	000-0054	19.4N	117.3E	000-0066	-----	------	--------
11	10/1100Z	15.7N	124.3E	15.5N	124.3E	17.6N	120.7E	054-0060	19.6N	117.0E	013-0054	22.2N	113.8E	305-0102
12	10/1700Z	16.2N	123.4E	15.8N	123.2E	18.1N	119.7E	049-0060	20.2N	116.1E	349-0066	-----	------	--------
13	10/2300Z	16.2N	122.1E	16.0N	122.1E	18.3N	118.3E	022-0030	21.1N	115.2E	334-0096	24.6N	113.3E	309-0132
14	11/0500Z	16.7N	121.0E	16.6N	120.9E	18.7N	117.1E	345-0024	21.2N	113.9E	299-0108	-----	------	--------
15	11/1100Z	17.3N	119.9E	17.0N	119.8E	19.3N	116.3E	326-0042	22.0N	113.1E	290-0132	-----	------	--------
16	11/1700Z	17.9N	118.6E	17.4N	118.8E	20.3N	115.0E	312-0102	23.2N	112.0E	289-0180	-----	------	--------
17	11/2300Z	17.9N	118.1E	17.8N	118.1E	19.4N	114.6E	262-0078	21.5N	111.4E	245-0228	-----	------	--------
18	12/0500Z	18.2N	117.3E	18.3N	117.3E	19.6N	114.2E	244-0090	21.7N	111.1E	238-0264	-----	------	--------
19	12/1100Z	18.4N	116.9E	18.7N	116.8E	19.7N	114.2E	217-0108	21.5N	111.4E	--------	-----	------	--------
20	12/1700Z	19.0N	116.2E	19.1N	116.4E	20.8N	113.4E	229-0126	23.4N	110.8E	--------	-----	------	--------
21	12/2300Z	19.7N	116.1E	19.6N	116.0E	20.8N	115.5E	175-0144	22.9N	114.4E	--------	-----	------	--------
22	13/0500Z	20.1N	115.8E	20.3N	115.7E	22.0N	115.1E	180-0126	-----	------	--------	-----	------	--------
23	13/1100Z	20.7N	115.5E	21.2N	115.4E	23.1N	114.8E	--------	-----	------	--------	-----	------	--------
24	13/1700Z	21.5N	115.3E	22.2N	115.2E	24.8N	115.0E	--------	-----	------	--------	-----	------	--------
25	13/2300Z	22.9N	115.2E	23.2N	115.2E	-----	------	--------	-----	------	--------	-----	------	--------
26	14/0500Z	23.6N	115.1E	24.1N	115.2E	-----	------	--------	-----	------	--------	-----	------	--------

AVERAGE 24 HOUR ERROR - 0069 MI.
AVERAGE 48 HOUR ERROR - 0114 MI.
AVERAGE 72 HOUR ERROR - 0116 MI.

H. TYPHOON HOPE 20 SEP 0500Z-29 SEP 0500Z

1. STATISTICS

a. Number of Warnings Issued - 37

b. Number of Warnings with Typhoon Intensity - 27

c. Distance Traveled During Warning Period - 3,034 MI

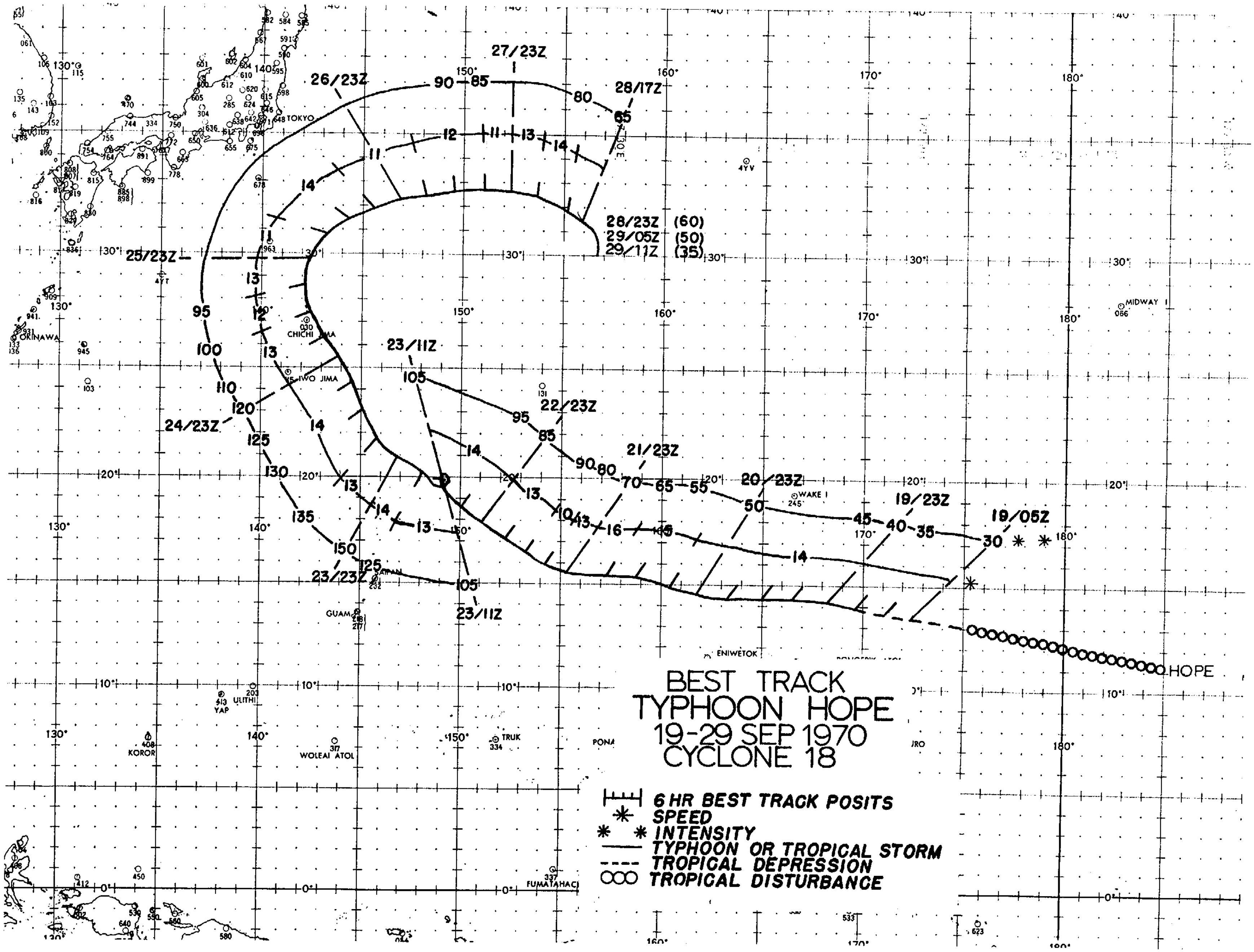
2. CHARACTERISTICS AS A TYPHOON

a. Minimum Observed SLP - 895 MBS at 23/2100Z

b. Minimum Observed 700 MB Height - 2219 M at 23/2100Z

c. Maximum Surface Wind - 150 KTS (From Best Track)

d. Maximum Radius of Surface Circulation - 180 MI


BEST TRACK
TYPHOON HOPE
19-29 SEP 1970
CYCLONE 18
6 HR BEST TRACK POSITS
SPEED
INTENSITY
TYPHOON OR TROPICAL STORM
TROPICAL DEPRESSION
TROPICAL DISTURBANCE
HOPE
TOKYO
OKINAWA
CHICHI JIMA
IWO JIMA
GUAM
WAKE I
MIDWAY I
ENIWETOK
ULITHI
YAP
KOROR
WOLEAI ATOL
TRUK
PONA
FUMATAHACI
19/05Z
19/23Z
20/23Z
21/23Z
22/23Z
23/11Z
23/23Z
24/23Z
25/23Z
26/23Z
27/23Z
28/17Z
28/23Z (60)
29/05Z (50)
29/11Z (35)

3. TYPHOON HOPE NARRATIVE

Hope spent her seven day period of typhoon intensity describing a parabolic track around the September mean position of the subtropical high pressure system in the West Pacific.

Digitized ITOS-1 mosaics indicate that the initial disturbance can be tracked back to the Central Pacific south of Johnston Island as early as the 14th. Successive mosaics showed the system to move westward about 5 degrees of longitude per day with an apparent slowdown on crossing the International Date Line. On the 19th a reconnaissance aircraft was dispatched from Wake Island to the suspect area and located a weak circulation north of the Marshall Islands with a 1007 mb central pressure.

The tropical cyclone progressed on a west northwest course north of the Caroline Islands at 14 to 15 knots for the next two days. Upon reaching typhoon intensity early on the 22nd, Hope changed to a northwestward course as the ridge line weakened in the vicinity of 145-150°E. The storm moved on this heading for two days and continued to deepen reaching super typhoon force during the night of the 23rd to 24th. (See Figure 5-15.)

The 200 mb pattern at this time resembled that described by Miller (1957) as favorable for maximum intensity for hurricanes. An upper tropospheric trough extending from Southern Japan and west of Iwo Jima was stationed to the northwest of the typhoon. This combined with Hope's already large upper level anticyclone, provided considerable evacuation of mass outflow to the westerlies.

Aerial reconnaissance at daybreak on the 24th logged a central pressure of 895 mb, the lowest to occur in the Northern Hemisphere during 1970. When compared with the dropsonde reading 24 hours earlier of 979 mb, this represented a phenomenal drop of some 84 mb[2]. A 14.5°C rise in temperature was noted on penetration at the 700 mb level with 27°C recorded inside the eight mile diameter eye. Maximum winds at this time were estimated to be 150 knots.

The typhoon dropped below super status the following morning as it neared the Volcano Island group on a slightly more northward course. The center passed 30 miles east of Chi Chi Jima the evening of the 25th with the island reporting

---

[4]A drop of 87 mb in 24 hours was observed in IDA-1958, as the typhoon reached a record low central pressure of 877 mb (see Jordan, 1959).

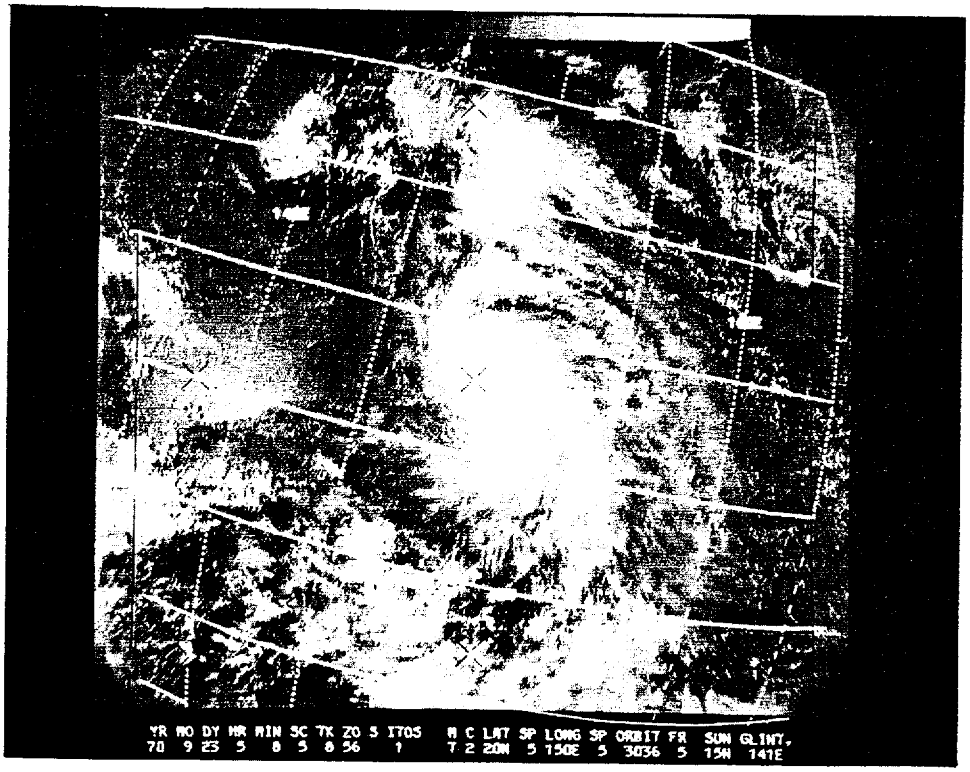


FIGURE 5-15 ITOS-1 VIEW OF SUPER TYPHOON HOPE ON THE AFTERNOON OF 23 SEPTEMBER DURING PERIOD OF MAXIMUM DEEPENING.

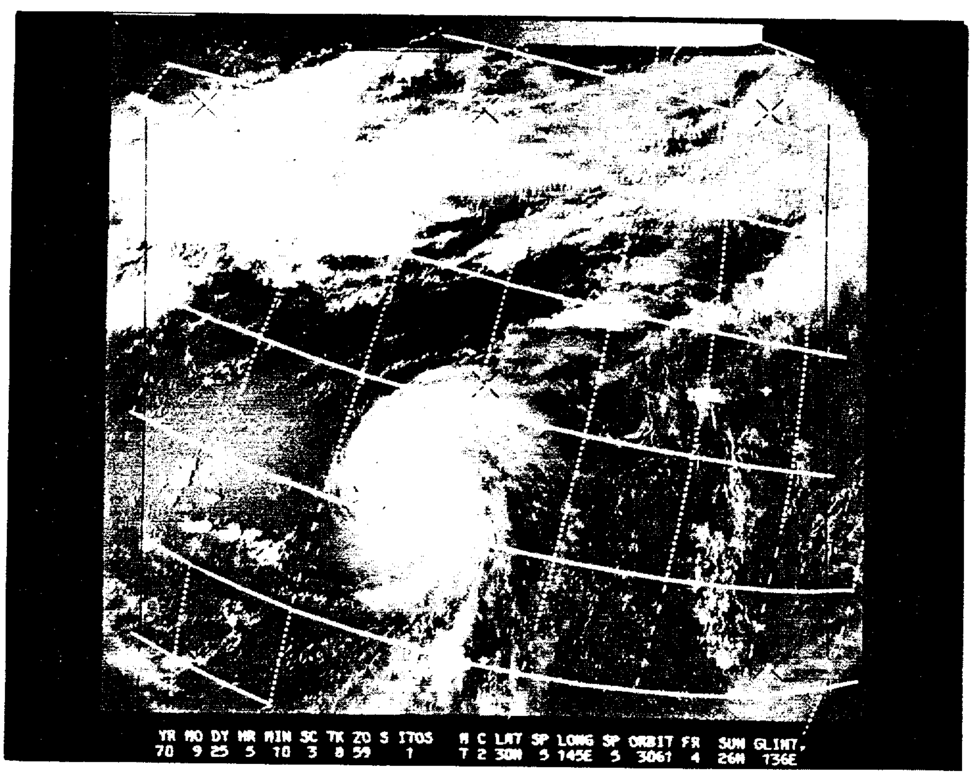


FIGURE 5-16 TYPHOON HOPE AS SEEN BY ITOS-1 ON 25 AUGUST A SHORT DISTANCE FROM CHI CHI JIMA ISLAND.

45 knot sustained and wind gusts to 89 knots with a barometer reading of 972.5 mb (Figure 5-16).

Hope shortly thereafter began to recurve and shift to a northeastward heading on the 26th. Like Clara, the storm was too far south to be accelerated northeast by an approaching short wave in the westerlies. By the next day it was forced on an easterly track by the northerly component behind this trough. However, the steering eventually pushed Hope south of east on the 28th toward the Mid-Pacific 200 mb shear line. This effectively reduced Hope to less than typhoon intensity in a 12 hour period as outflow from the system was impeded. As the storm drifted further south and under the shear aloft, it weakened to depression status and began to describe an anticyclonic hook to the west as it slowly dissipated.

The marked demise of a developed typhoon remaining over warm waters is an unusual event in the West Pacific, however, a not too infrequent occurrence in the Atlantic. Similar cases are mentioned by Sugg and Pelisser (1968) in discussion of Hurricane Beulah in the Western Carribean in 1967 and Simpson, Sugg and Staff (1970) for Hurricane Holly in the Atlantic in 1969.

TYPHOON HOPE

EYE FIXES CYCLONE 18

FIX NO.	TIME	POSIT	UNIT-METHOD-ACCY	FLT LVL	FLT LVL WND	OBS SFC WND	OBS MIN SLP	MIN 700MB HGT	FLT LVL TT/TO	EYE FORM	ORIEN-TATION	EYE DIA	CHARACTER WALL CLOUD
1	190520Z	13.0N 172.4E	VW-P-05---		---	030	007	---	25/23	----			----------
2	200410Z	14.0N 166.3E	SLTLS	STG B	DIA --	CAT -							----------
3	200625Z	14.2N 166.2E	VW-P-05---		---	050	997	---	24/25	----			----------
4	202314Z	14.7N 161.7E	54-P-05---	700MB	050	065	995	3057	14/11	----			NEG W/C
5	210314Z	13.4N 161.1E	54-P-05---	700MB	035	050	998	3060	13/11	----			NEG W/C
6	210510Z	14.2N 159.8E	SLTLS	STG C	DIA --	CAT -							----------
7	210925Z	15.2N 159.4E	VW-P-05---		040	030	---	---	--/--	CIRC	----	12	OPEN NE-W
8	211415Z	15.1N 158.0E	VW-P-10---		035	035	997	---	26/25	CIRC	----	24	OPEN NE-SW
9	212100Z	15.5N 156.0E	54-P-10---	700MB	050	095	998	3042	15/12	CIRC	----	20	CLSD NW-SE
10	220000Z	15.5N 155.2E	54-P-10---	700MB	040	095	000	3072	15/09	CIRC	----	10	CLSD NE-SE
11	220300Z	15.5N 154.6E	54-P-10---	700MB	055	100	987	3011	16/10	ELIP	N-S	18X--	CLSD NW-S
12	220412Z	15.8N 155.8E	SLTLS	STG C	DIA --	CAT -							----------
13	220530Z	15.8N 154.6E	54--------	0040M	---	---	---	---	--/--	CIRC	----	15	----------
14	220958Z	16.4N 153.6E	VW-P-05---		---	---	---	---	--/--	CIRC	----	15	CLSD
15	221145Z	16.3N 153.3E	VW-P-05---	6500M	---	---	953	---	15/11	ELIP	NW-SE	25X--	OPEN N
16	221245Z	16.4N 153.3E	ACFT RDR		---	---	---	---	--/--	----			----------
17	221500Z	16.8N 152.7E	VW-P-05---	6940M	---	---	951	2804	16/09	ELIP	NW-SE	25X--	W/C WEST QUAD
18	222100Z	17.5N 151.6E	54-P-08---	700MB	095	070	976	2920	15/10	CIRC	----	19	WC N-S-WSW
19	230000Z	17.7N 151.1E	54-P-10---	700MB	100	080	974	2877	17/12	CIRC	----	15	CLSD
20	230300Z	18.2N 150.6E	54-P-12---	700MB	070	100	969	2859	17/09	----			CLSD, APRNT TWO WALLS
21	230508Z	18.9N 150.0E	SLTLS	STG X	DIA 0	CAT 4							----------
22	230820Z	19.5N 149.2E	VW-P-04---	700MB	095	100	---	2643	20/09	----			CLSD, W/C & FB CONC
23	231200Z	20.1N 149.1E	VW-P-06---		---	---	---	---	--/--	----			CLSD 5NM THK
24	231425Z	19.7N 148.8E	VW-P-04---	700MB	110	---	---	2627	22/09	CIRC	----	08	CLSD ALQUADS, 5NM THK
25	232100Z	20.5N 147.5E	54-P-01---	700MB	110	100	895	2219	27/12	CIRC	----	08	CLSD ALQUADS, 3NM THK
26	240300Z	21.1N 146.5E	54-P-10---	700MB	140	110	906	2240	26/12	CIRC	----	04	W/C CLSD 5NM THK
27	240604Z	22.5N 146.5E	SLTLS	STG X	DIA 04	CAT 3							----------
28	241022Z	22.6N 145.6E	VW-P-15---		---	---	---	---	--/--	CIRC	----	07	CLSD
29	241427Z	23.6N 144.8E	VW-P-10---		---	---	---	---	--/--	CIRC	----	10	CLSD
30	242100Z	24.8N 144.2E	54-P-10---	700MB	105	120	936	2554	17/09	CIRC	----	12	5NM THK, OPEN S
31	250300Z	25.9N 143.3E	54-P-10---	700MB	100	120	944	2603	15/12	CIRC	----	15	OPEN S
32	250510Z	25.6N 143.0E	SLTLS	STG X	DIA 04	CAT 4							----------
33	250900Z	26.8N 142.7E	VW-P-02---	0460M	060	070	---	---	--/--	ELIP	NE-SW	30X20	W/C SW-NE 11NM THK
34	251205Z	27.2N 143.0E	VW-P-10---	0500M	---	---	---	---	--/--	CIRC	----	40	12NM THK, OPEN S
35	251510Z	28.0N 142.2E	VW-P-05---	700MB	115	---	957	2707	21/11	CIRC	----	22	OPEN S
36	252100Z	29.2N 142.2E	54-P-05---	700MB	085	080	949	2740	17/13	CIRC	----	28	OPEN S
37	260300Z	30.2N 142.7E	54-P-05---	700MB	085	080	950	2722	17/12	CIRC	----	25	CLSD
38	260606Z	30.3N 144.0E	SLTLS	STG X	DIA 0	CAT 4							----------
39	260842Z	30.8N 143.4E	VW-P-05---	0310M	---	---	---	---	--/--	CIRC	----	21	OPEN SE
40	261200Z	31.4N 144.7E	VW-P-05---	4540M	---	---	---	---	--/--	CIRC	----	20	CLSD
41	261505Z	31.5N 145.1E	VW-P-05---	700MB	095	---	949	2585	18/12	CIRC	----	35	OPEN SOMEWHAT IRREG
42	262100Z	32.2N 146.5E	54-P-06---	700MB	095	100	955	2694	17/15	CIRC	----	50	CLSD
43	270000Z	32.4N 147.0E	54-P-06---	700MB	098	110	954	2704	17/15	CIRC	----	50	CLSD
44	270300Z	32.3N 147.5E	54-P-05---	700MB	085	115	958	2734	17/14	CIRC	----	50	OPEN NNE
45	270507Z	32.0N 148.0E	SLTLS	STG X	DIA 0	CAT 3							----------
46	270900Z	32.5N 149.2E	VW- -10---		065	050	---	---	--/--	CIRC	----	50	12NM THK, OPEN N QUAD
47	271224Z	33.1N 149.7E	VW-P-10---		105	085	966	---	26/19	ELIP	NE-SW	32X32	18NM THK, OPEN SW QUAD
48	271440Z	32.6N 150.7E	VW-P-20---		---	---	---	---	--/--	----			----------

TYPHOON HOPE

EYE FIXES CYCLONE 19

FIX NO.	TIME	POSIT	UNIT-METHOD-ACCY	FLT LVL	FLT LVL WND	OBS SFC WND	OBS MIN SLP	MIN 700MB HGT	FLT LVL TT/TD	EYE FORM	ORIEN-TATION	EYE DIA	CHARACTER WALL CLOUD
49	271530Z	32.5N 150.9E	VW-P-10---		085	---	---	---	--/--	CIRC	----	42	OPEN 12NM THK, OPEN S-W
50	272100Z	32.7N 151.7E	54-P-05---	700MB	087	100	968	2847	23/17	CIRC	----	40	POORLY DEF, OPEN S & W
51	280409Z	32.5N 153.5E	SLTLS	STG X	DIA 03	CAT 3							----------
52	280440Z	32.3N 153.5E	54-P-03---	700MB	055	120	968	2902	26/23	CIRC	----	40	W/C NE QUAD
53	280900Z	31.9N 154.8E	VW-P-15---		---	---	---	---	--/--	CIRC	----	70	OPEN S, DISORG
54	280935Z	32.1N 155.1E	VW-P-07---		---	060	977	---	25/21	CIRC	----	60	OPEN S W/C NE QUAD
55	281400Z	32.0N 155.6E	VW-P-30---		---	---	---	---	--/--	----			NEG W/C
56	290030Z	30.9N 156.6E	54-P-30---	700MB	---	060	997	3091	17/14	----			NEG W/C
57	290300Z	30.9N 156.5E	54-P-20---	4580M	---	060	996	---	24/--	----			NEG W/C
58	290505Z	30.3N 156.5E	SLTLS	STG -	DIA --	CAT -							----------

TYPHOON HOPE

TROPICAL CYCLONE 18 -- 9/19/1700Z TO 9/29/0500Z
POSITION AND FORECAST VERIFICATION DATA

WARN		WARNING POSIT		BEST TRACK		24 HR FCST		24 HR ERROR	48 HR FCST		48 HR ERROR	72 HR FCST		72 HR ERROR
NO.	DTG	LAT	LONG	LAT	LONG	LAT	LONG	DEG DIST	LAT	LONG	DEG DIST	LAT	LONG	DEG DIST
01	20/0500Z	14.1N	166.6E	14.2N	166.5E	15.5N	161.4E	057-0060	17.1N	157.2E	066-0180	-----	------	--------
02	20/1100Z	14.4N	165.3E	14.2N	164.9E	15.8N	160.2E	062-0084	17.6N	156.1E	066-0168	19.0N	152.2E	104-0186
03	20/1700Z	14.7N	164.0E	14.2N	163.3E	16.2N	159.1E	063-0114	18.1N	154.9E	068-0156	-----	------	--------
04	20/2300Z	14.7N	161.7E	14.3N	161.8E	15.5N	155.3E	----0000	16.7N	149.7E	233-0096	18.1N	144.5E	220-0204
05	21/0500Z	14.1N	160.6E	14.9N	160.4E	14.1N	154.5E	173-0102	15.1N	148.8E	197-0228	-----	------	--------
06	21/1100Z	15.2N	159.0E	15.1N	158.8E	16.0N	153.5E	153-0024	17.3N	148.7E	185-0150	19.5N	144.8E	187-0216
07	21/1700Z	15.2N	157.3E	15.3N	157.3E	16.2N	151.8E	204-0054	17.8N	147.2E	202-0144	-----	------	--------
08	21/2300Z	15.5N	155.4E	15.5N	155.3E	16.5N	148.9E	241-0144	18.4N	143.4E	234-0240	20.5N	138.8E	226-0402
09	22/0500Z	15.6N	154.1E	15.8N	154.2E	16.8N	147.8E	227-0174	18.9N	142.3E	230-0264	-----	------	--------
10	22/1100Z	16.3N	153.4E	16.4N	153.3E	18.2N	149.2E	172-0096	19.8N	144.9E	186-0198	21.9N	141.3E	191-0324
11	22/1700Z	17.1N	152.4E	17.1N	152.3E	18.7N	148.2E	180-0084	20.3N	143.9E	188-0234	-----	------	--------
12	22/2300Z	17.8N	151.2E	17.7N	151.1E	20.2N	146.9E	180-0036	22.5N	142.9E	200-0174	25.4N	139.8E	209-0288
13	23/0500Z	18.4N	150.2E	18.8N	150.0E	21.1N	146.1E	171-0042	23.7N	142.3E	196-0156	-----	------	--------
14	23/1100Z	19.8N	149.1E	19.8N	149.0E	25.2N	147.0E	036-0150	28.9N	144.4E	047-0138	33.5N	145.4E	023-0138
15	23/1700Z	20.1N	148.4E	20.1N	148.2E	23.7N	145.6E	116-0066	27.3N	143.8E	132-0114	-----	------	--------
16	23/2300Z	20.9N	147.1E	20.8N	146.9E	24.2N	143.0E	220-0084	28.0N	140.8E	220-0132	32.9N	143.4E	281-0174
17	24/0500Z	21.4N	146.1E	21.8N	146.0E	24.3N	142.3E	200-0126	27.7N	140.3E	220-0222	-----	------	--------
18	24/1100Z	22.4N	145.2E	23.1N	145.3E	26.5N	142.0E	201-0048	30.9N	142.1E	259-0114	36.3N	147.3E	334-0246
19	24/1700Z	24.0N	144.4E	24.2N	144.5E	29.6N	143.0E	035-0072	35.0N	146.8E	017-0204	-----	------	--------
20	24/2300Z	25.2N	144.0E	25.3N	144.0E	30.3N	143.2E	046-0048	36.9N	148.6E	017-0288	-----	------	--------
21	25/0500Z	26.4N	143.2E	26.3N	143.1E	31.9N	144.0E	029-0084	38.8N	150.3E	016-0402	-----	------	--------
22	25/1100Z	27.4N	142.5E	27.3N	142.4E	32.7N	144.4E	005-0084	42.0N	152.5E	014-0576	-----	------	--------
23	25/1700Z	28.4N	142.2E	28.6N	142.2E	33.7N	145.5E	360-0120	-----	------	--------	-----	------	--------
24	25/2300Z	29.6N	142.3E	29.7N	142.4E	35.4N	147.7E	011-0186	-----	------	--------	-----	------	--------
25	26/0500Z	30.7N	143.0E	30.6N	143.1E	36.2N	150.2E	024-0252	-----	------	--------	-----	------	--------
26	26/1100Z	31.2N	144.2E	31.3N	144.3E	37.3N	153.6E	036-0342	-----	------	--------	-----	------	--------
27	26/1700Z	31.8N	145.6E	31.7N	145.6E	-----	------	--------	-----	------	--------	-----	------	--------
28	26/2300Z	32.3N	146.8E	32.3N	146.9E	33.9N	152.2E	360-0084	33.7N	159.3E	040-0204	-----	------	--------
29	27/0500Z	32.3N	147.9E	32.3N	148.1E	32.3N	152.5E	270-0060	31.8N	158.6E	061-0120	-----	------	--------
30	27/1100Z	32.5N	149.6E	32.6N	149.5E	32.5N	155.5E	019-0036	32.8N	162.1E	--------	-----	------	--------
31	27/1700Z	32.5N	151.5E	32.6N	151.0E	32.5N	157.8E	058-0108	-----	------	--------	-----	------	--------
32	27/2300Z	32.6N	152.2E	32.5N	152.3E	32.6N	157.8E	033-0108	-----	------	--------	-----	------	--------
33	28/0500Z	32.4N	153.6E	32.3N	153.7E	32.3N	159.3E	057-0162	-----	------	--------	-----	------	--------
34	28/1100Z	32.1N	155.5E	31.9N	155.2E	32.0N	161.4E	--------	-----	------	--------	-----	------	--------
35	28/1700Z	32.0N	156.3E	31.5N	155.9E	32.1N	161.8E	--------	-----	------	--------	-----	------	--------
36	28/2300Z	31.2N	156.5E	31.0N	156.6E	-----	------	--------	-----	------	--------	-----	------	--------
37	29/0500Z	30.9N	156.5E	30.8N	156.5E	-----	------	--------	-----	------	--------	-----	------	--------

AVERAGE 24 HOUR ERROR - 0101 MI.
AVERAGE 48 HOUR ERROR - 0204 MI.
AVERAGE 72 HOUR ERROR - 0242 MI.

I. TYPHOON IRIS 03 OCT 2300Z-08 OCT 0500Z

1. STATISTICS

   a. Number of Warnings Issued - 18

   b. Number of Warnings with Typhoon Intensity - 11

   c. Distance Traveled During Warning Period - 492 MI

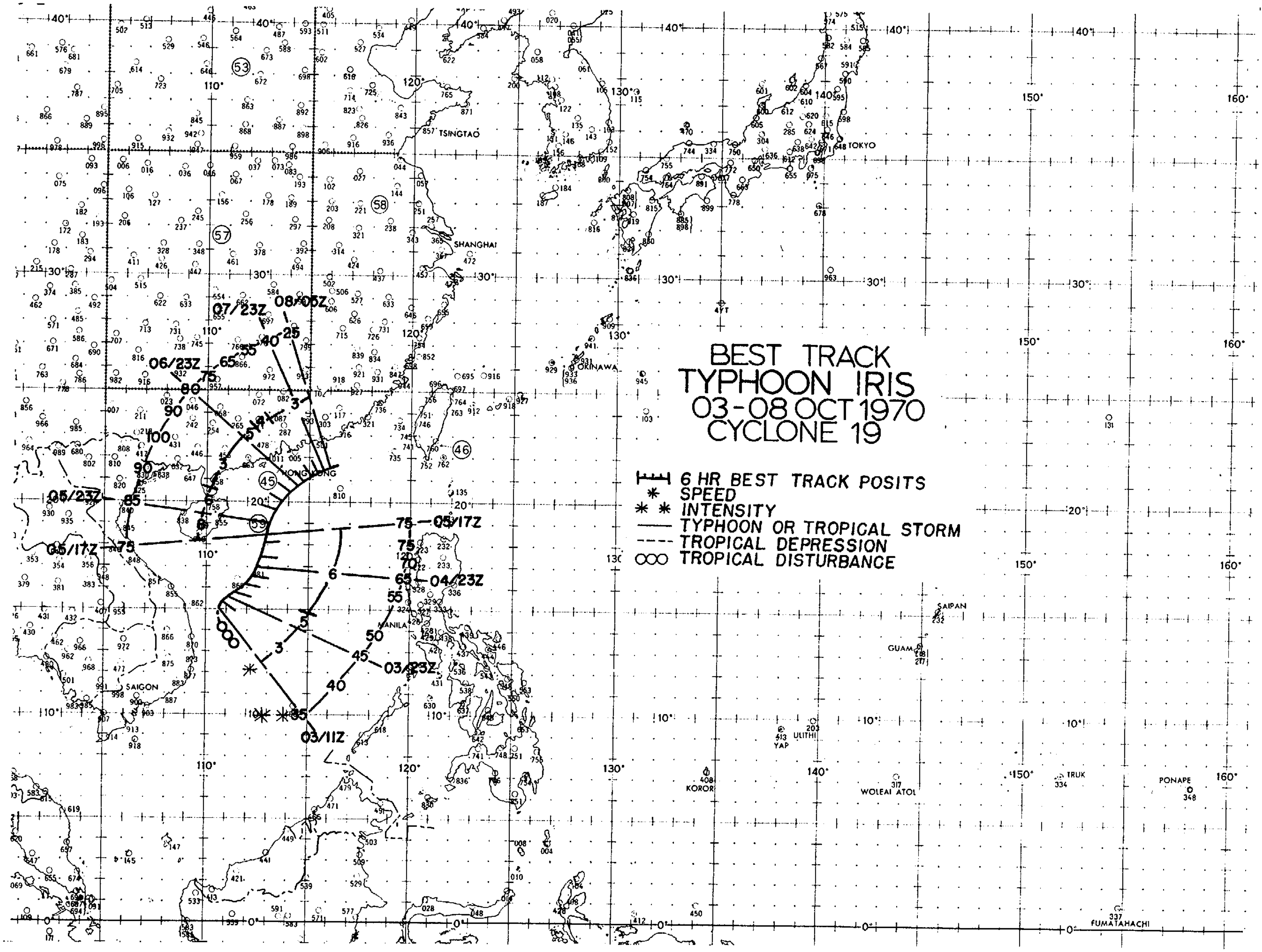
2. CHARACTERISTICS AS A TYPHOON

   a. Minimum Observed SLP - 944 MBS at 06/0902Z

   b. Minimum Observed 700 MB Height - 2743 M at 06/0315Z

   c. Maximum Surface Wind - 100 KTS (From Best Track)

   d. Maximum Radius of Surface Circulation - 180 MI


BEST TRACK
TYPHOON IRIS
03-08 OCT 1970
CYCLONE 19
6 HR BEST TRACK POSITS
* SPEED
* * INTENSITY
TYPHOON OR TROPICAL STORM
TROPICAL DEPRESSION
TROPICAL DISTURBANCE
03/11Z
03/23Z
04/23Z
05/17Z
05/23Z
06/23Z
07/23Z
08/05Z
HONG KONG
MANILA
SAIGON
SHANGHAI
TSINGTAO
TOKYO
OKINAWA
SAIPAN
GUAM
ULITHI
YAP
KOROR
WOLEAI ATOL
TRUK
PONAPE
FUMATAHACHI

3. TYPHOON IRIS NARRATIVE

Iris was the first tropical storm in the waters of the South China Sea to develop to typhoon strength in the month of October since 1957.

A surge in the northeast monsoon late in September created a rather sharp northeast to southwest shear line across the South China Sea by early October. This intensified the lower tropospheric cyclonic shear in the western portion of the area and as the surge began to recede on the 2nd, a small weak circulation remained off the Vietnam Coast.

Evidence of a developing storm became apparent on the 3rd as gradient level winds (3,000 feet) along the central Vietnam Coast ran as high as 46 knots while showing a sharp cyclonic curvature. An aerial reconnaissance investigation on the 4th located Iris 135 miles east of Quang Ngai with maximum winds of 45 knots, a weak wall cloud, and a central pressure of 992 mb.

With the presence of a southern extension of a mid-tropospheric ridge to the east of the storm and a weak trough to the northwest, Iris moved at a rate of 5 to 6 knots towards the northeast. Evidence of further deepening was noted during the morning of the 5th (Figure 5-17) as the USS Chipola passed within 3 miles of the eye recording a barometer drop to 985 mb, while the Chinese weather station in the Parcel Island group, 10 miles west of the center, reported winds of 68 knots.

A jet max associated with a 200 mb trough in central China provided the main mechanism for outflow from the system as Iris reached its maximum intensity the afternoon of the 6th about 140 miles south of Hong Kong. Aerial reconnaissance at this time observed a central pressure of 944 mb and winds estimated near 100 knots.

The eye of Iris came under surveillance of the Hong Kong Royal Observatory radar early on the 7th (Figure 5-18) and commenced to slow to a forward speed of 3 knots. The system completely collapsed in less than a 24 hour period as a 200 mb short wave emerging from the Gulf of Tonkin arrived in the vicinity on the 7th. Upon drifting over the storm the confluent pattern aloft inhibited any further outflow from the storm and by the following afternoon the typhoon was reduced to little more than a depression. All traces of Iris had disappeared by the 9th.

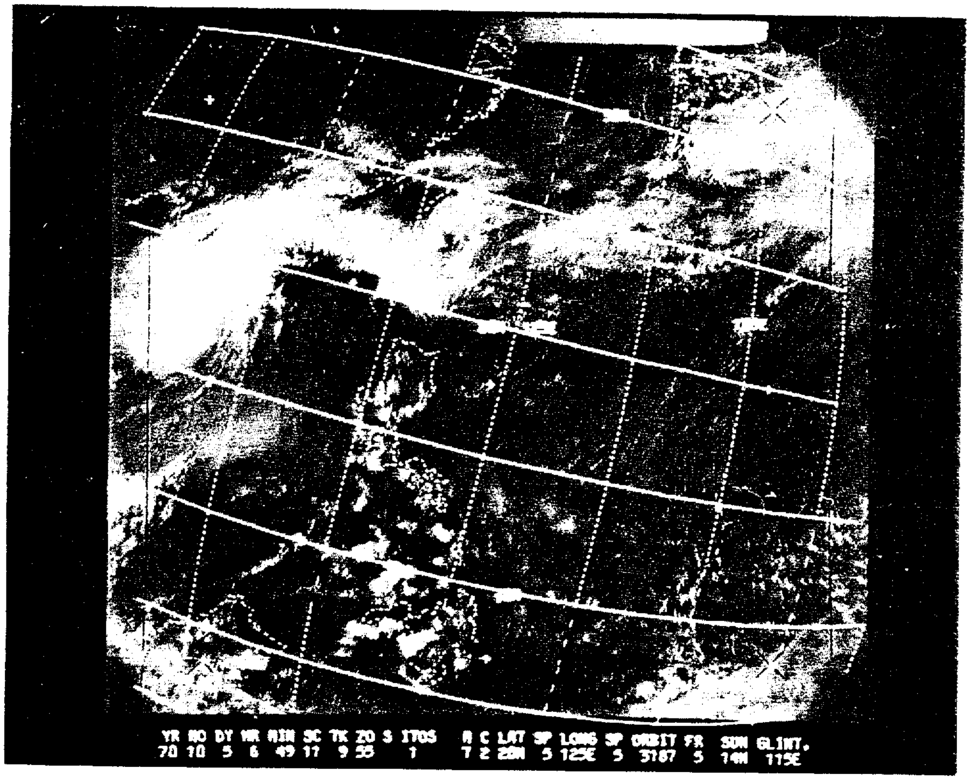


FIGURE 5-17 ITOS-1 PHOTO OF IRIS THE AFTERNOON OF 5 OCTOBER AS A NEWLY DEVELOPED TYPHOON.

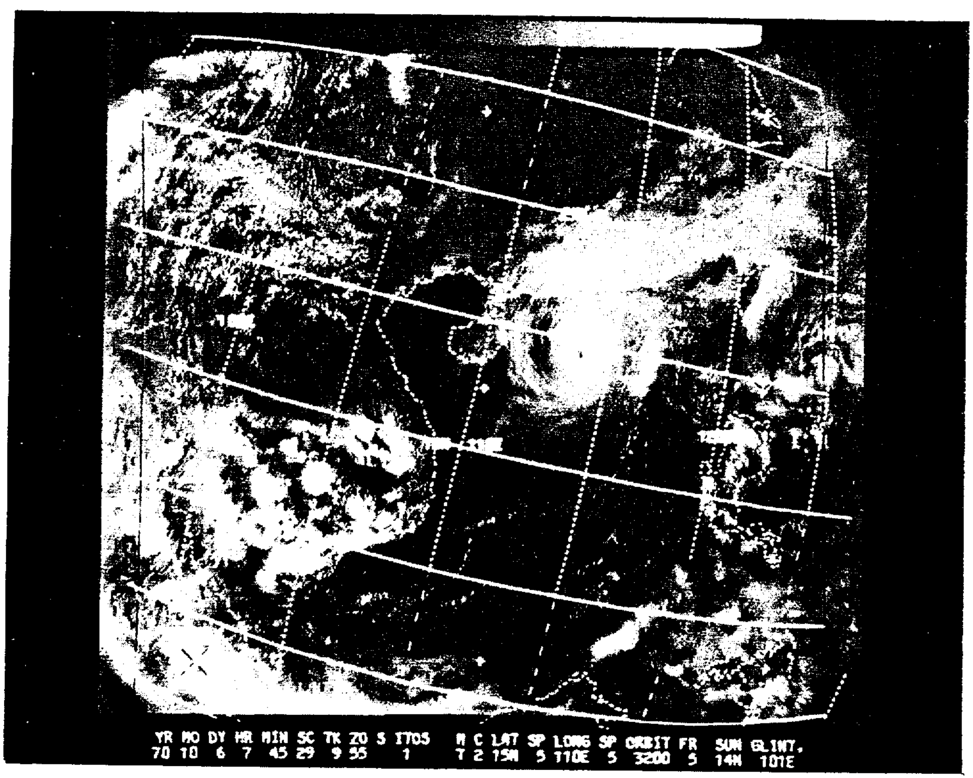


FIGURE 5-18 TYPHOON IRIS LOCATED SOUTH OF HONG KONG ON 7 OCTOBER.

TYPHOON IRIS
EYE FIXES CYCLONE 19

FIX NO.	TIME	POSIT	UNIT-MET OJ-ACCY	FLT LVL	FLT LVL WND	OBS SFC WND	OBS MIN SLP	MIN 700MB HGT	FLT LVL TT/TO	EYE FORM	ORIEN-TATION	EYE DIA	CHARACTER WALL CLOUD
1	040012Z	15.5N 111.4E	VW-P-10---		---	045	992	---	26/24	CIRC	----	29	WK W/C CLOSED
2	040200Z	15.9N 111.2E	LND RDR		---	---	---	---	--/--	----			----------
3	040315Z	15.6N 111.3E	VW-P-05---		---	050	990	---	26/23	----			CLSD 8-15NM THK
4	040400Z	16.0N 111.3E	LND RDR		---	---	---	---	--/--	----			----------
5	040610Z	15.7N 111.6E	54-P-05---	700MB	045	045	994	3027	15/10	CIRC	----	40	APRNT CLSD W/C
6	040748Z	15.5N 111.5E	SLTLS	STG C	DIA --	CAT -							----------
7	050130Z	17.4N 112.6E	SHIP RDR		---	---	---	---	--/--	----			----------
8	050320Z	17.3N 112.5E	VW-P-05---		---	---	---	---	--/--	----			CLSD
9	050649Z	17.5N 112.5E	SLTLS	STG X	DIA 02	CAT 4							----------
10	050801Z	17.8N 112.9E	VW-P-05---	700MB	090	075	973	2911	26/23	ELIP	NW-SE	18X--	CLSD ALQUADS 5-7NM THK
11	051440Z	18.4N 113.0E	VW-P-07---		015	---	---	---	--/--	CIRC	----	15	CLSD
12	052031Z	19.0N 113.0E	VW-P-10---		---	---	---	---	--/--	CIRC	----	14	CLSD 5-7NM THK
13	052200Z	19.0N 113.1E	LND RDR		---	---	---	---	--/--	----			----------
14	060100Z	19.4N 113.2E	LND RDR		---	---	---	---	--/--	----			----------
15	060315Z	19.6N 113.4E	54-P-07---	700MB	090	080	960	2743	16/09	CIRC	----	21	CLSD
16	060535Z	19.8N 113.7E	54-P-05---	700MB	080	090	960	2749	15/09	CIRC	----	18	CLSD
17	060600Z	19.7N 113.5E	LND RDR		---	---	---	---	--/--	----			----------
18	060746Z	19.5N 113.5E	SLTLS	STG X	DIA 0[illegible]	CAT 4							----------
19	060900Z	19.7N 113.7E	LND RDR		---	---	---	---	--/--	----			----------
20	060902Z	19.9N 113.9E	VW-P-10---		---	100	944	---	24/23	CIRC	----	23	CLSD
21	061000Z	19.9N 113.7E	LND RDR		---	---	---	---	--/--	----			----------
22	061200Z	20.0N 113.9E	LND RDR		---	---	---	---	--/--	----			----------
23	061400Z	20.3N 114.4E	VW-P-20---		---	---	---	---	--/--	ELIP	NW-SE	25X12	12NM THK, OPEN S
24	061900Z	20.3N 113.9E	LND RDR		---	---	---	---	--/--	----			----------
25	062200Z	20.4N 114.0E	LND RDR		---	---	---	---	--/--	CIRC	----	42	----------
26	062300Z	20.4N 114.1E	LND RDR		---	---	---	---	--/--	CIRC	----	42	----------
27	070000Z	20.5N 114.2E	LND RDR		---	---	---	---	--/--	CIRC	----	34	----------
28	070125Z	20.6N 114.5E	54-P-03---	700MB	090	090	975	2896	18/09	CIRC	----	20	CLSD
29	070400Z	20.7N 114.6E	LND RDR		---	---	---	---	--/--	CIRC	----	30	----------
30	070425Z	20.8N 114.7E	54-P-03---	700MB	085	080	980	2920	17/08	CIRC	----	20	W/C DSIPTG SE QUAD
31	070600Z	20.8N 114.7E	LND RDR		---	---	---	---	--/--	CIRC	----	32	----------
32	070647Z	22.0N 115.5E	SLTLS	STG X	DIA 0[illegible]	CAT 3							----------
33	070800Z	20.8N 114.8E	LND RDR		---	---	---	---	--/--	----			----------
34	071000Z	20.9N 115.2E	LND RDR		---	---	---	---	--/--	----			----------
35	071100Z	20.8N 115.2E	LND RDR		---	---	---	---	--/--	----			----------
36	071400Z	21.1N 115.7E	LND RDR		---	---	---	---	--/--	----			----------

TYPHOON IRIS

TROPICAL CYCLONE 19 -- 10/3/1100Z TO 10/8/0500Z
POSITION AND FORECAST VERIFICATION DATA

WARN NO.	DTG	WARNING POSIT LAT	WARNING POSIT LONG	BEST TRACK LAT	BEST TRACK LONG	24 HR FCST LAT	24 HR FCST LONG	24 HR ERROR DEG DIST	48 HR FCST LAT	48 HR FCST LONG	48 HR ERROR DEG DIST	72 HR FCST LAT	72 HR FCST LONG	72 HR ERROR DEG DIST
01	03/2300Z	15.5N	111.3E	15.4N	111.0E	15.5N	111.3E	217-0108	15.1N	109.7E	219-0324	-----	------	--------
02	04/0500Z	15.6N	111.3E	15.6N	111.4E	15.6N	111.3E	215-0138	15.2N	109.7E	221-0360	-----	------	--------
03	04/1100Z	15.7N	111.6E	16.0N	111.8E	15.7N	111.6E	208-0150	15.3N	109.5E	222-0378	-----	------	--------
04	04/1700Z	16.2N	112.5E	16.4N	112.2E	17.4N	114.1E	140-0090	-----	------	--------	-----	------	--------
05	04/2300Z	17.0N	112.4E	17.0N	112.5E	18.9N	114.3E	113-0054	20.9N	117.1E	084-0150	22.7N	121.0E	075-0306
06	05/0500Z	17.5N	112.8E	17.5N	112.7E	19.4N	114.7E	116-0048	21.1N	116.8E	082-0114	-----	------	--------
07	05/1100Z	18.0N	113.2E	18.0N	112.9E	20.1N	115.4E	086-0084	22.6N	118.9E	067-0234	-----	------	--------
08	05/1700Z	18.5N	113.3E	18.6N	113.0E	20.3N	115.5E	090-0078	22.4N	118.7E	068-0198	-----	------	--------
09	05/2300Z	19.3N	113.1E	19.3N	113.3E	22.1N	113.4E	329-0102	-----	------	--------	-----	------	--------
10	06/0500Z	19.8N	113.8E	19.8N	113.8E	22.4N	114.1E	342-0096	-----	------	--------	-----	------	--------
11	06/1100Z	20.1N	114.1E	20.0N	113.9E	21.8N	116.2E	054-0078	23.9N	118.0E	--------	-----	------	--------
12	06/1700Z	20.6N	114.7E	20.3N	114.1E	22.3N	116.7E	048-0102	24.4N	118.4E	--------	-----	------	--------
13	06/2300Z	20.5N	114.4E	20.6N	114.4E	21.9N	115.1E	326-0042	23.3N	115.6E	--------	-----	------	--------
14	07/0500Z	20.8N	114.6E	20.8N	114.7E	22.2N	115.3E	--------	23.7N	115.7E	--------	-----	------	--------
15	07/1100Z	21.1N	114.9E	21.0N	115.0E	22.2N	115.3E	--------	-----	------	--------	-----	------	--------
16	07/1700Z	21.6N	115.0E	21.1N	115.3E	-----	------	--------	-----	------	--------	-----	------	--------
17	07/2300Z	21.1N	115.5E	21.3N	115.6E	-----	------	--------	-----	------	--------	-----	------	--------
18	08/0500Z	21.3N	115.8E	-----	------	-----	------	--------	-----	------	--------	-----	------	--------

AVERAGE 24 HOUR ERROR - 0090 MI.
AVERAGE 48 HOUR ERROR - 0251 MI.
AVERAGE 72 HOUR ERROR - 0306 MI.

J. TYPHOON JOAN 09 OCT 2300Z-18 OCT 0500Z

1. STATISTICS

   a. Number of Warnings Issued - 34

   b. Number of Warnings with Typhoon Intensity - 25

   c. Distance Traveled During Warning Period - 2,254 MI

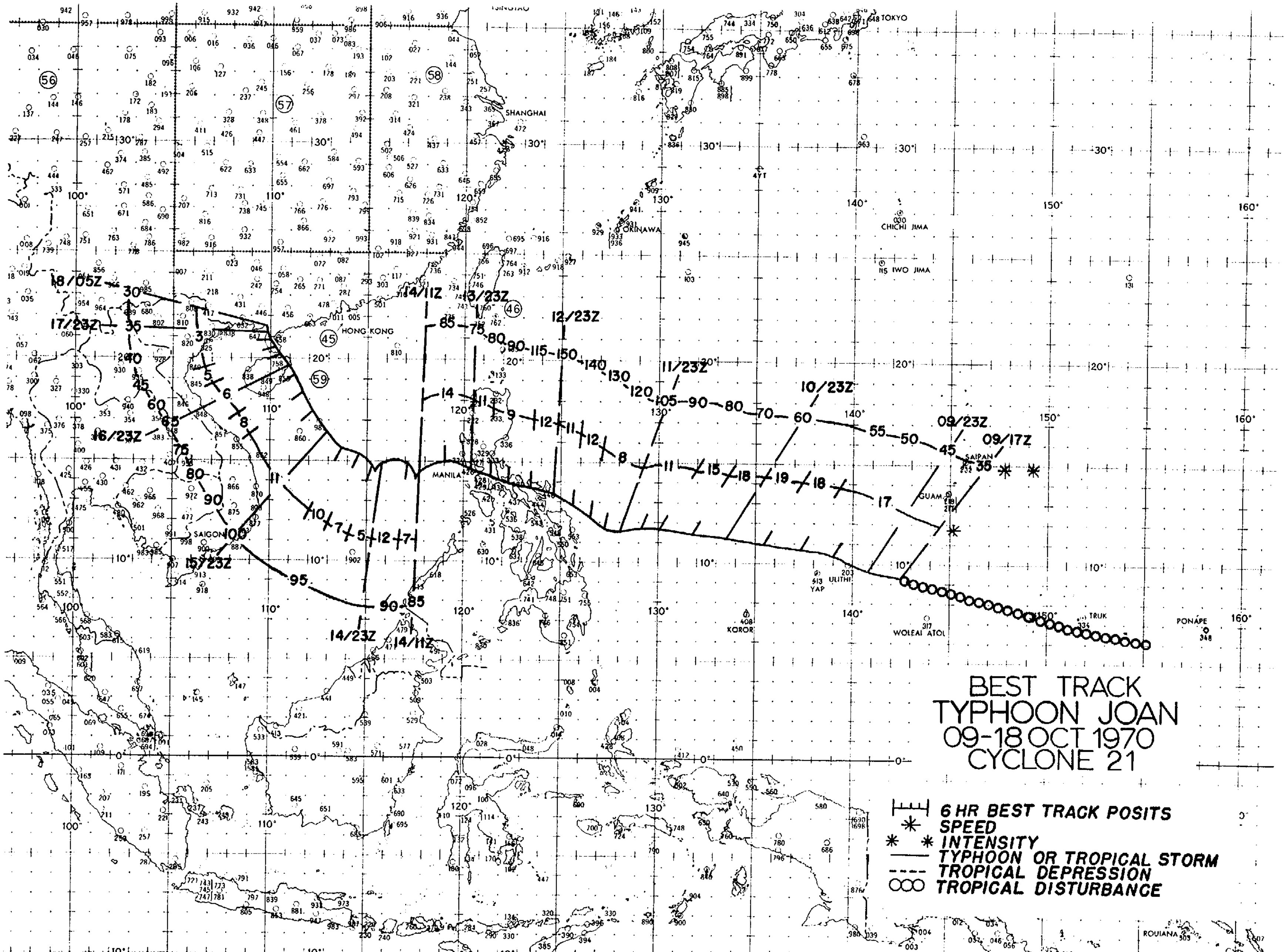
2. CHARACTERISTICS AS A TYPHOON

   a. Minimum Observed SLP - 901 MBS at 12/2100Z

   b. Minimum Observed 700 MB Height - 2332 M at 12/2100Z

   c. Maximum Surface Wind - 150 KTS (From Best Track)

   d. Maximum Radius of Surface Circulation - 720 MI


BEST TRACK
TYPHOON JOAN
09-18 OCT 1970
CYCLONE 21
6 HR BEST TRACK POSITS
SPEED
INTENSITY
TYPHOON OR TROPICAL STORM
TROPICAL DEPRESSION
TROPICAL DISTURBANCE
TOKYO
SHANGHAI
HONG KONG
MANILA
SAIGON
OKINAWA
CHICHI JIMA
IWO JIMA
SAIPAN
GUAM
YAP
ULITHI
KOROR
WOLEAI ATOL
TRUK
PONAPE
09/17Z
09/23Z
10/23Z
11/23Z
12/23Z
13/23Z
14/11Z
14/23Z
15/23Z
16/23Z
17/23Z
18/05Z

3. TYPHOON JOAN NARRATIVE

Joan was the first of two sister super typhoons to strike the Republic of the Philippines within a period of a week.

The disturbance which was to become Joan entered on stage in the Truk-Ponape area of the Caroline Islands on the 8th of October. Upper air data revealed the existence of a 200 mb circulation two days earlier and by the 8th a downward reflection of the system appeared as a wave in the surface pressure pattern. Meanwhile, the subtropical ridge was strengthening, producing a tightening pressure gradient and resulting in favorable relative vorticity pattern for increasing mass inflow into the system. As a consequence of the strong easterly trades the wave disturbance began a westward movement of 17 knots. A surface circulation developed by the morning of the 9th and that afternoon, Joan passed Ulithi Atoll having reached tropical storm force.

Upon achieving typhoon intensity by noon the 11th, the storm's forward speed reduced to 11 knots while it moved within the southern periphery of a 200 mb anticyclone situated 300 miles southeast of Okinawa. In response to the increasing divergence pattern aloft, the central pressure began to drop steadily from 976 to 924 mb by late the following afternoon. As Joan approached super typhoon intensity, she reacted to a weakness in the ridge line and shifted to a more northwesterly component, thus aiming the storm at the southeastern peninsula of Luzon.

The cooler upper tropospheric environment of westerlies surrounding the typhoon's northern periphery served as a marked zone of contrast to the vast quantities of warm air being pumped out from the wall cloud region during this deepening period. The strong thermal wind effect in this area of merging air contributed to the production of an upper jet of westerly winds extending over a considerable distance. Evidence of the extensive outflow in existence on October 12th is depicted by the generation of a long band of cirrus stretching some 1,200 miles from Manila to Guam (see Figure 5-19). The narrow jet along the northern and eastern periphery of Joan was present as far east as Guam which reported at 200 mb west northwesterly winds of 50 knots.

The severity the typhoon had attained was testified to by an aerial reconnaissance crew which entered Joan before daybreak on the 13th. Upon penetration of the wall cloud region, the aircraft encountered severe turbulence accompanied by a "g" load force of 2.5. Once in the eye, the closed wall cloud topping above 35,000 feet gave a stadium bowl effect as revealed

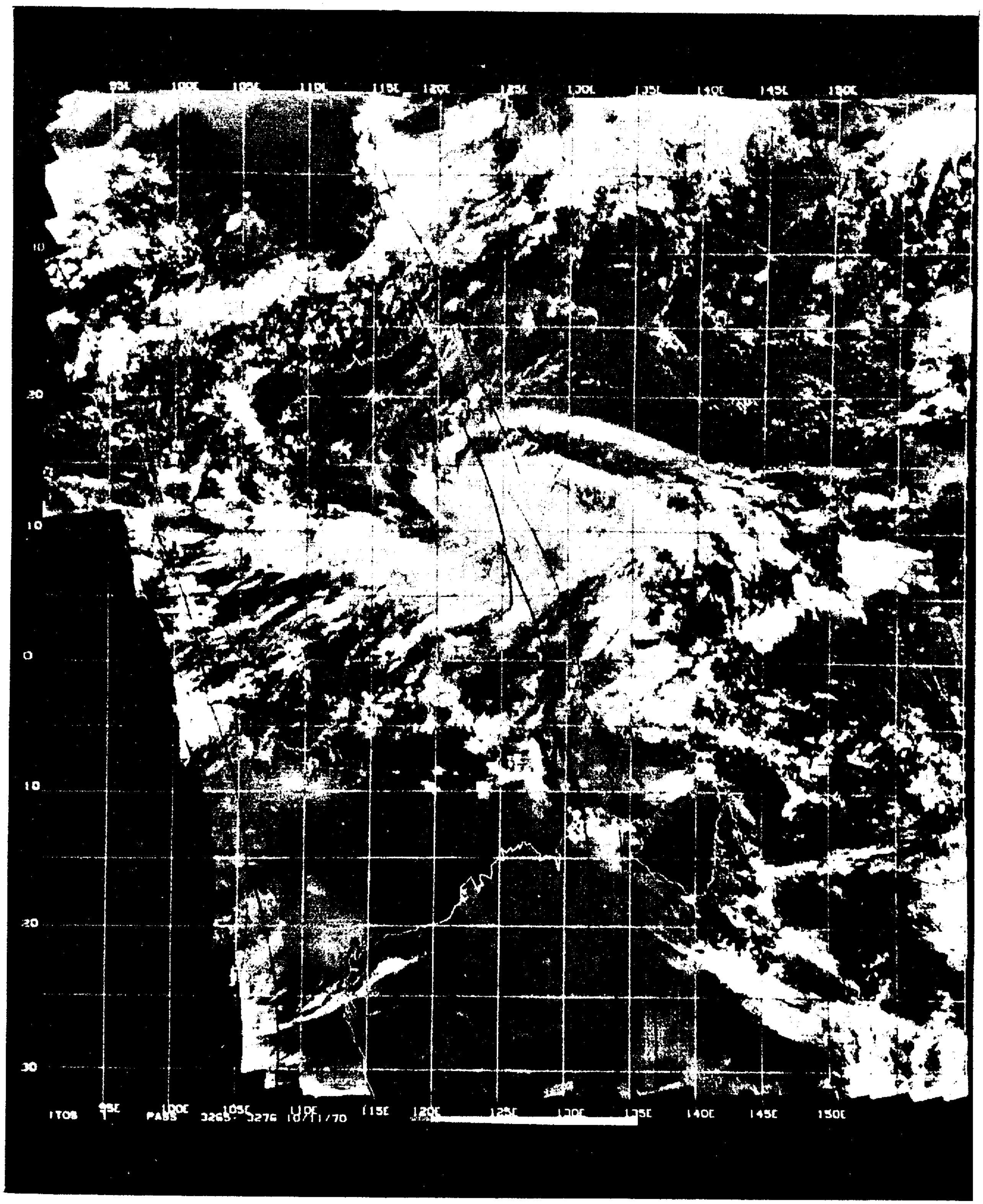


FIGURE 5-19 ITOS-1 MOSAIC ON 12 OCTOBER (LOCAL SUN TIME) DEPICTING EXTENSIVE CIRRUS BAND ON THE PERIPHERY OF TYPHOON JOAN'S OUTFLOW REGION.

by the continuous lightning occurring in all quadrants of the encircling coliseum. A dropsonde reading of 901 mb and max 700 mb temperature of 23.5°C was obtained while orbiting in the 25 mile diameter eye. Maximum surface wind occurring under the wall cloud region was estimated at 150 knots as daylight began. Looking for a weakness in the radar return to avoid further encounters with severe turbulence, the aircraft was forced to climb to 22,000 feet before exit was made. The temperature recorded at 500 mb during this climb was measured at +8.4°C.

Joan made landfall near noon in the Lagonoy Gulf region of southeastern Luzon after skirting the southern coast of Catanduanes Island. The U. S. Coast Guard loran station on the island, 30 miles north of the center, registered winds of 90 knots gusting to 110 knots before the anemometer failed. Lowest barometer reading was 973 mb. On the southern portion of the island the Philippine Weather Bureau station at Virac was heavily damaged but recorded a minimum sea level pressure of 950.7 mb and winds estimated near 150 knots.

The typhoon swept through the southern extent of Luzon moving across Bicol and Tagalog provinces and gradually losing strength. Passing some 20 miles south of Manila on the morning of the 14th, the International airport reported peak gusts of 84 knots and a 976.9 mb pressure reading while the Coast Guard vessel USCGC Blackhaw anchored in Manila Bay sustained gusts of 75 knots.

Upon her entrance in the South China Sea, aircraft fixes traced a cycloidal track during the 14th and 15th. The trajectory over rugged terrain of Luzon had disorganized the vertical structure around the central eye region of Joan. Apparently, the surface center was showing an oscillating behavior while embedded within a more stable upper center describing a uniform westerly track.

During this time frame, the area of gale force winds grew in size to more than 250 miles in radius from the center while the eye diameter expanded to some 80 miles. This area filled almost the entire northern half of the South China Sea ranking Joan as the largest typhoon in size in 1970 (Figure 5-20). The shipping traffic in this region felt its fury as at least one 390-foot vessel was in distress for over 24 hours.

A slow moving trough in the westerlies over Central China began to weaken the ridge line along 105-115°E on the 15th. This provided a path for a more northward component and Joan headed on a course toward the northeastern tip of Hainan on the morning of the 17th. It was of minimal typhoon strength and weakened considerably on passage up the Luichow Peninsula

slowly dissipating further inland over South China.

The typhoon left in its wake some 575 people dead and 1,590 injured, plus an additional 193 missing in the Republic of the Philippines. Damage was estimated near 74 million dollars (U.S.) with at least 80,000 people reported to be homeless and an agricultural crop loss of 92 percent in the region affected. These figures rank the storm high on the list of most destrucitve to affect that country.

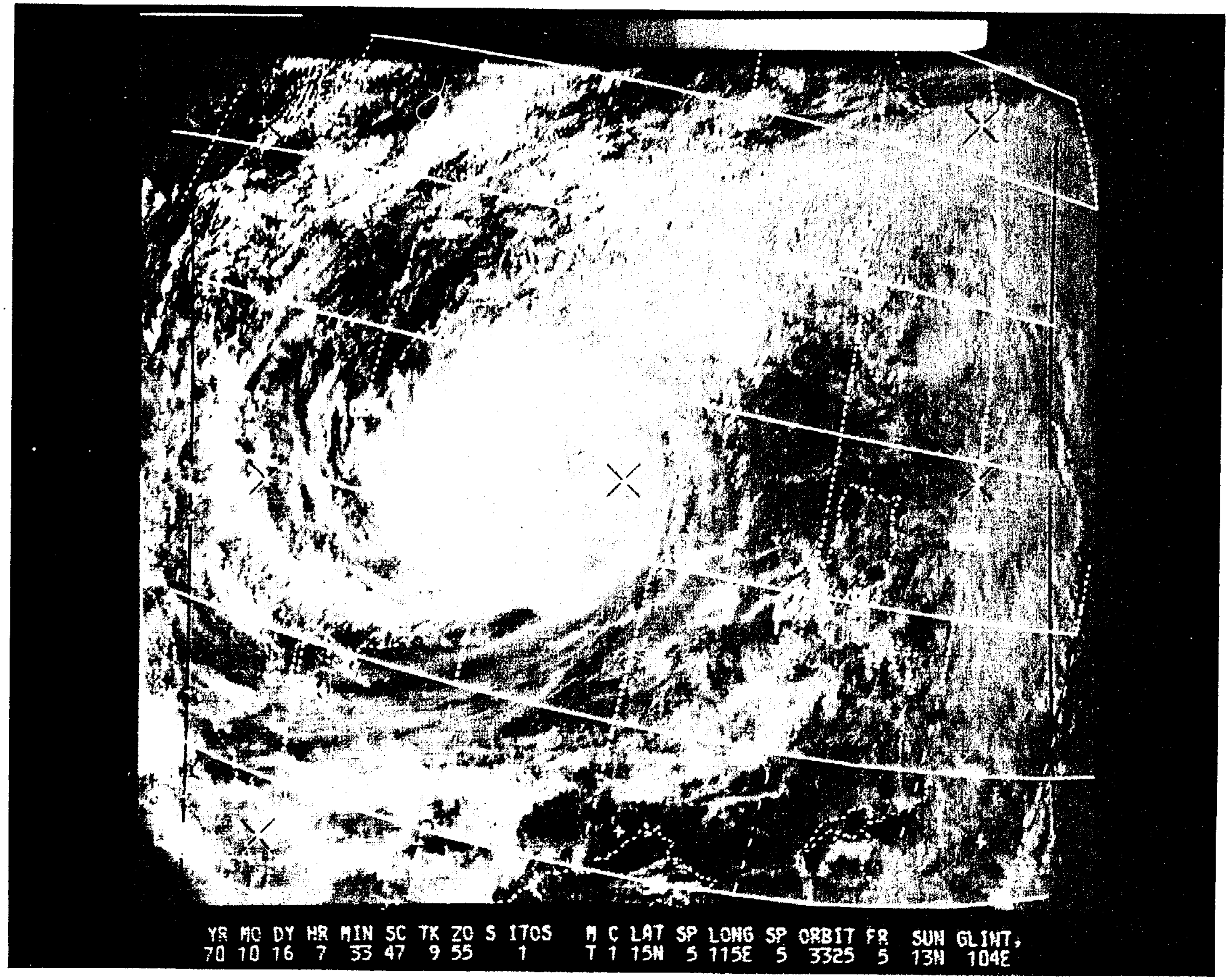


FIGURE 5-20 JOAN THE LARGEST TYPHOON IN SIZE DURING THE 1970 SEASON AS SEEN BY CAMERA'S ABOARD ITOS-1 ON 16 OCTOBER.

TYPHOON JOAN

EYE FIXES CYCLONE 21

FIX NO.	TIME	POSIT	UNIT-METHOD-ACCY	FLT LVL	FLT LVL WND	OBS SFC WND	OBS MIN SLP	MIN 700MB HGT	FLT LVL TT/TD	EYE FORM	ORIENTATION	EYE DIA	CHARACTER WALL CLOUD
1	090450Z	09.0N 144.0E	SLTLS	STG B	DIA --	CAT -							----------
2	092345Z	09.5N 140.4E	54-P-15---	0500M	048	045	997	---	25/23	----			----------
3	100300Z	10.0N 139.6E	54-P-01---	700MB	048	035	986	3011	13/11	CIRC	----	10	W/C NE SEMICIR
4	100546Z	09.5N 137.5E	SLTLS	STG X	DIA 04	CAT 2							----------
5	100600Z	10.3N 138.7E	54-P-05---	700MB	050	045	987	2987	13/10	----			NO ORG W/C
6	100846Z	10.6N 138.0E	VW-P-03---	0320M	---	055	993	---	21/23	CIRC	----	25	WK W/C 6NM THK, OPEN NNE
7	101447Z	10.8N 136.1E	VW-P-05---	0320M	---	055	990	3030	24/20	CIRC	----	27	12NM THK, OPEN NNE
8	102100Z	11.0N 134.0E	54-P-05---	700MB	045	060	990	2996	14/08	CIRC	----	25	OPEN NW-E QUAD
9	110300Z	11.2N 132.3E	54-P-05---		060	070	976	2902	15/10	CIRC	----	25	OPEN E-SW
10	110642Z	11.0N 132.5E	SLTLS	STG X	DIA 03	CAT 2							----------
11	110910Z	11.5N 130.7E	VW-P-03---	0430M	074	075	978	---	24/20	CIRC	----	15	3NM THK, WK S-W
12	111100Z	11.6N 130.5E	VW--------		---	---	---	---	--/--	----			----------
13	111200Z	11.7N 130.0E	VW--------		---	---	---	---	--/--	CIRC	----	25	----------
14	111430Z	11.7N 130.1E	VW-P-10---	700MB	100	---	---	2908	12/07	CIRC	----	30	CLSD 12NM THK
15	112100Z	11.4N 128.4E	54-P-10---	700MB	092	---	959	2752	22/13	ELIP	N-S	27X22	SML BRKS IN W/C
16	120300Z	11.4N 127.3E	54-P-10---	700MB	---	110	943	2615	20/11	CIRC	----	23	OPEN NW
17	120530Z	11.5N 127.1E	54-P-10---	700MB	068	120	938	2570	20/10	CIRC	----	25	CLSD
18	120544Z	12.0N 127.0E	SLTLS	STG X	DIA 03	CAT 4							----------
19	120915Z	11.9N 127.0E	VW-P-07---	0270M	---	130	924	---	27/23	CIRC	----	16	CLSD 6NM THK
20	121200Z	12.4N 126.7E	LND RDR		---	---	---	---	--/--	CIRC	----	25	----------
21	121400Z	12.4N 126.3E	VW-P-03---		---	---	---	---	--/--	CIRC	----	14	CLSD
22	121600Z	12.8N 126.0E	LND RDR		---	---	---	---	--/--	CIRC	----	25	----------
23	121800Z	13.0N 125.7E	LND RDR		---	---	---	---	--/--	CIRC	----	30	----------
24	121900Z	13.1N 125.5E	LND RDR		---	---	---	---	--/--	CIRC	----	55	----------
25	122100Z	12.9N 125.2E	54-P-05---	700MB	110	150	901	2332	24/14	CIRC	----	25	CLSD 6NM THK
26	122300Z	13.4N 124.6E	LND RDR		---	---	---	---	--/--	CIRC	----	30	----------
27	130000Z	13.5N 124.6E	LND RDR		---	---	---	---	--/--	----			----------
28	130200Z	13.6N 124.0E	LND RDR		---	---	---	---	--/--	----			----------
29	130300Z	13.6N 123.7E	LND RDR		---	---	---	---	--/--	----			----------
30	130330Z	13.6N 123.5E	LND RDR		---	---	---	---	--/--	----			----------
31	130400Z	13.6N 123.6E	LND RDR		---	---	---	---	--/--	----			----------
32	130500Z	13.6N 123.3E	LND RDR		---	---	---	---	--/--	----			----------
33	130500Z	13.6N 123.4E	LND RDR		---	---	---	---	--/--	----			----------
34	130530Z	13.5N 123.3E	LND RDR		---	---	---	---	--/--	----			----------
35	130630Z	13.7N 123.1E	LND RDR		---	---	---	---	--/--	----			----------
36	130640Z	14.0N 123.0E	SLTLS	STG X	DIA 04	CAT 4							----------
37	130803Z	13.8N 122.9E	LND RDR		---	---	---	---	--/--	----			----------
38	130858Z	13.8N 122.8E	VW-P-05---	700MB	050	---	---	2990	--/--	CIRC	----	10	BRKN, POORLY DEF
39	131000Z	13.8N 122.7E	LND RDR		---	---	---	---	--/--	----			----------
40	131030Z	13.7N 122.7E	LND RDR		---	---	---	---	--/--	----			----------
41	131100Z	13.8N 122.6E	LND RDR		---	---	---	---	--/--	----			----------
42	131130Z	13.8N 122.5E	LND RDR		---	---	---	---	--/--	----			----------
43	131230Z	13.9N 122.4E	LND RDR		---	---	---	---	--/--	----			----------
44	131300Z	14.0N 122.3E	LND RDR		---	---	---	---	--/--	----			----------
45	131330Z	14.0N 122.2E	LND RDR		---	---	---	---	--/--	----			----------
46	131402Z	13.9N 122.2E	VW-P-02---		---	---	---	---	--/--	CIRC	----	09	POORLY DEF
47	131500Z	14.1N 122.0E	LND RDR		---	---	---	---	--/--	----			----------
48	131730Z	14.4N 121.6E	LND RDR		---	---	---	---	--/--	----			----------

TYPHOON JOAN

EYE FIXES CYCLONE 21

FIX NO.	TIME	POSIT	UNIT-METHOD-ACCY	FLT LVL	FLT LVL WND	OBS SFC WND	OBS MIN SLP	MIN 700MB HGT	FLT LVL TT/TD	EYE FORM	ORIEN-TATION	EYE DIA	CHARACTER WALL CLOUD
49	131800Z	14.5N 121.5E	LND RDR		---	---	---	---	--/--	----			----------
50	131830Z	14.5N 121.4E	LND RDR		---	---	---	---	--/--	----			----------
51	131840Z	14.6N 121.3E	LND RDR		---	---	---	---	--/--	----			----------
52	131900Z	14.5N 121.3E	LND RDR		---	---	---	---	--/--	----			----------
53	131930Z	14.4N 121.2E	LND RDR		---	---	---	---	--/--	----			----------
54	132030Z	14.6N 121.0E	LND RDR		---	---	---	---	--/--	----			----------
55	132100Z	14.2N 121.2E	54-P-02---	500MB	050	---	---	---	-2/-6	CIRC	----	18	CLSD, POORLY DEF
56	132130Z	14.6N 120.7E	LND RDR		---	---	---	---	--/--	----			----------
57	140030Z	14.5N 120.4E	LND RDR		---	---	---	---	--/--	----			----------
58	140140Z	14.6N 120.2E	LND RDR		---	---	---	---	--/--	----			----------
59	140300Z	14.9N 119.6E	54-P-02---	500MB	040	080	968	---	-2/-4	CIRC	----	25	REFORMG NE-W
60	140540Z	15.1N 118.5E	LND RDR		---	---	---	---	--/--	----			----------
61	140737Z	14.5N 118.0E	SLTLS	STG X	DIA 05	CAT 3							----------
62	140830Z	14.8N 118.0E	LND RDR		---	---	---	---	--/--	----			----------
63	141000Z	14.5N 117.5E	LND RDR		---	---	---	---	--/--	----			----------
64	141200Z	14.1N 117.5E	LND RDR		---	---	---	---	--/--	----			----------
65	141212Z	14.1N 117.5E	LND RDR		---	---	---	---	--/--	----			----------
66	141239Z	14.2N 117.7E	VW-P-10---	700MB	---	---	---	2871	17/14	CIRC	----	50	POORLY DEF
67	141419Z	14.1N 117.6E	VW-P-04---	0500M	---	065	977	---	27/24	CIRC	----	35	OPEN N-E-S
68	142115Z	15.1N 116.4E	54-P-15---	700MB	080	---	967	2838	17/14	CIRC	----	40	OPEN E-W
69	150000Z	14.8N 115.8E	54-P-03---	700MB	065	065	966	2813	17/14	CIRC	----	45	OPEN E-S
70	150200Z	14.5N 115.4E	54-P-03---	700MB	050	065	965	2813	18/15	CIRC	----	40	OPEN N-SE
71	150830Z	15.1N 115.1E	VW-P-40---		---	---	---	---	--/--	----			----------
72	150833Z	15.5N 115.0E	SLTLS	STG X	DIA 07	CAT 3							----------
73	151404Z	15.4N 114.3E	VW-P-05---		115	125	958	---	24/22	ELIP	NW-SE	75X30	OPEN N
74	152045Z	16.0N 113.3E	54-P-05---	700MB	085	---	952	2707	17/13	ELIP	NE-SW	80X50	BRKS NW-NE
75	160320Z	17.0N 113.6E	54-P-05---	700MB	080	100	952	2704	21/13	ELIP	NW-SE	99X--	BRKN NE-SW
76	160734Z	18.0N 112.0E	SLTLS	STG X	DIA 06	CAT 4							----------
77	160900Z	18.0N 111.9E	VW-P-10---		060	055	---	---	--/--	CIRC	----	80	25-35NM THK, OPEN NE-SE
78	161514Z	18.7N 111.8E	VW-P-15---		---	---	---	---	--/--	----			W/C S-N
79	170830Z	21.0N 110.0E	SLTLS	STG X	DIA 02	CAT 3							----------

TYPHOON JOAN

TROPICAL CYCLONE 21 -- 10/9/1700Z TO 10/18/0500Z
POSITION AND FORECAST VERIFICATION DATA

WARN NO.	DTG	WARNING POSIT LAT	WARNING POSIT LONG	BEST TRACK LAT	BEST TRACK LONG	24 HR FCST LAT	24 HR FCST LONG	24 HR ERROR DEG DIST	48 HR FCST LAT	48 HR FCST LONG	48 HR ERROR DEG DIST	72 HR FCST LAT	72 HR FCST LONG	72 HR ERROR DEG DIST
01	09/2300Z	9.4N	140.6E	9.5N	140.7E	11.6N	134.6E	060-0066	13.2N	128.9E	024-0114	15.2N	123.5E	329-0126
02	10/0500Z	10.3N	139.0E	10.2N	139.0E	12.8N	132.8E	036-0102	14.6N	127.0E	358-0186	-----	------	--------
03	10/1100Z	10.8N	137.3E	10.7N	137.3E	13.0N	131.1E	027-0090	15.0N	125.3E	335-0180	17.1N	119.9E	323-0240
04	10/1700Z	10.9N	135.4E	10.8N	135.4E	12.0N	129.0E	360-0030	13.9N	123.7E	298-0132	-----	------	--------
05	10/2300Z	11.1N	133.4E	11.0N	133.5E	12.0N	126.4E	291-0096	13.7N	120.3E	275-0240	16.0N	115.2E	286-0312
06	11/0500Z	11.3N	131.7E	11.4N	131.7E	12.3N	125.1E	291-0126	14.2N	119.3E	278-0240	-----	------	--------
07	11/1100Z	11.5N	130.2E	11.6N	130.3E	12.6N	124.1E	279-0150	14.4N	118.7E	279-0210	16.7N	113.9E	300-0258
08	11/1700Z	11.5N	129.6E	11.5N	129.1E	11.0N	124.8E	207-0120	12.0N	120.0E	214-0150	-----	------	--------
09	11/2300Z	11.3N	128.0E	11.4N	128.0E	11.4N	122.5E	228-0168	12.7N	117.3E	240-0204	14.5N	112.4E	264-0198
10	12/0500Z	11.5N	127.1E	11.5N	127.2E	11.9N	123.1E	191-0102	12.7N	119.1E	180-0138	-----	------	--------
11	12/1100Z	12.0N	126.8E	12.2N	126.7E	13.5N	124.0E	101-0090	14.5N	120.0E	090-0126	15.7N	116.0E	072-0072
12	12/1700Z	12.8N	126.1E	12.8N	125.8E	13.9N	122.4E	104-0048	14.9N	118.4E	090-0066	-----	------	--------
13	12/2300Z	13.0N	125.0E	13.3N	124.7E	14.0N	121.4E	119-0060	15.2N	117.4E	078-0084	16.8N	114.1E	069-0060
14	13/0500Z	13.7N	123.2E	13.6N	123.5E	15.0N	118.8E	270-0012	16.5N	114.9E	345-0096	-----	------	--------
15	13/1100Z	14.0N	122.3E	13.8N	122.4E	15.3N	117.9E	008-0048	16.6N	114.5E	355-0078	18.2N	111.6E	226-0012
16	13/1700Z	14.2N	121.6E	14.1N	121.5E	15.4N	117.6E	031-0030	16.8N	114.2E	020-0066	-----	------	--------
17	13/2300Z	14.5N	120.6E	14.5N	120.4E	15.7N	117.0E	046-0066	17.0N	113.8E	050-0054	18.6N	110.9E	180-0066
18	14/0500Z	14.9N	119.2E	15.0N	119.1E	16.4N	115.1E	352-0090	17.9N	112.1E	348-0030	-----	------	--------
19	14/1100Z	14.4N	117.5E	14.5N	117.8E	16.3N	116.3E	057-0108	17.9N	114.5E	101-0144	19.3N	113.1E	112-0174
20	14/1700Z	14.3N	118.0E	14.9N	117.2E	16.2N	116.5E	080-0162	17.7N	114.7E	114-0204	-----	------	--------
21	14/2300Z	14.9N	116.0E	14.9N	115.9E	15.5N	112.1E	222-0072	15.5N	108.8E	207-0276	-----	------	--------
22	15/0500Z	14.5N	115.2E	14.9N	115.4E	14.5N	111.7E	190-0174	14.5N	108.6E	199-0342	-----	------	--------
23	15/1100Z	15.0N	114.5E	15.3N	114.7E	15.0N	111.0E	194-0204	15.0N	107.9E	202-0342	-----	------	--------
24	15/1700Z	15.4N	114.0E	15.7N	113.7E	15.4N	110.7E	190-0222	15.8N	107.8E	200-0372	-----	------	--------
25	15/2300Z	16.1N	113.1E	16.4N	113.0E	18.0N	110.1E	206-0108	20.0N	108.0E	239-0126	-----	------	--------
26	16/0500Z	17.1N	112.2E	17.4N	112.3E	20.3N	110.4E	360-0018	23.0N	110.0E	--------	-----	------	--------
27	16/1100Z	18.5N	111.7E	18.4N	111.9E	22.9N	110.8E	012-0150	-----	------	--------	-----	------	--------
28	16/1700Z	19.0N	111.8E	19.1N	111.4E	22.2N	112.1E	075-0108	-----	------	--------	-----	------	--------
29	16/2300Z	19.7N	111.6E	19.7N	111.0E	21.6N	111.5E	069-0078	-----	------	--------	-----	------	--------
30	17/0500Z	19.7N	111.4E	20.0N	110.5E	20.4N	110.2E	--------	-----	------	--------	-----	------	--------
31	17/1100Z	19.9N	111.1E	20.4N	110.2E	20.7N	110.2E	--------	-----	------	--------	-----	------	--------
32	17/1700Z	20.8N	109.9E	21.7N	110.1E	22.5N	108.8E	--------	-----	------	--------	-----	------	--------
33	17/2300Z	21.0N	110.2E	21.1N	110.0E	-----	------	--------	-----	------	--------	-----	------	--------
34	18/0500Z	21.4N	110.1E	-----	------	-----	------	--------	-----	------	--------	-----	------	--------

AVERAGE 24 HOUR ERROR - 0099 MI. 99.8
AVERAGE 48 HOUR ERROR - 0168 MI.
AVERAGE 72 HOUR ERROR - 0151 MI.

K. TYPHOON KATE 15 OCT 0500Z-25 OCT 1100Z

1. STATISTICS

   a. Number of Warnings Issued - 42

   b. Number of Warnings with Typhoon Intensity - 34

   c. Distance Traveled During Warning Period - 2,317 MI

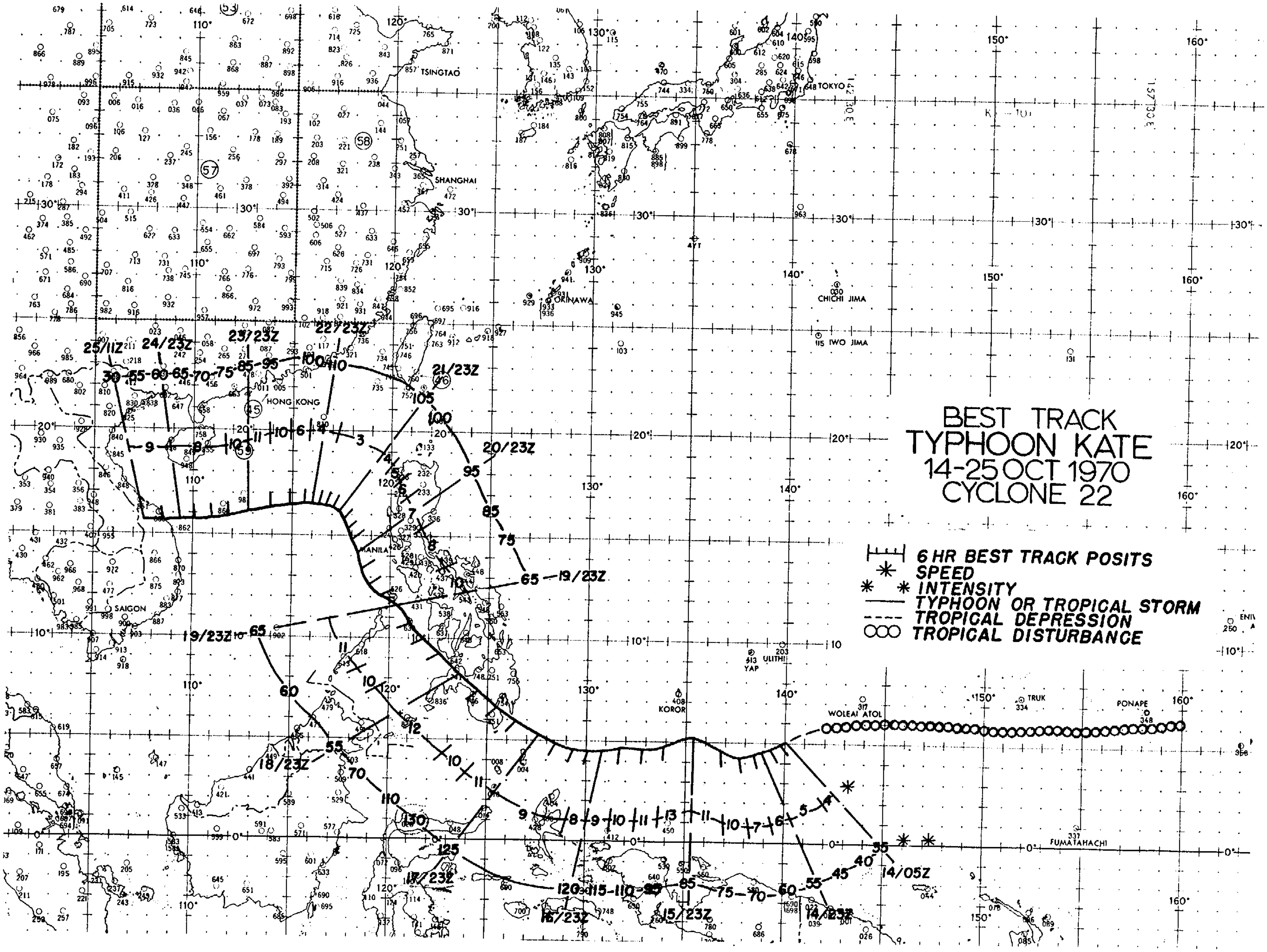
2. CHARACTERISTICS AS A TYPHOON

   a. Minimum Observed SLP - 938 MBS at 16/2100Z

   b. Minimum Observed 700 MB Height - 2554 M at 22/2100Z

   c. Maximum Surface Wind - 130 KTS (From Best Track)

   d. Maximum Radius of Surface Circulation - 540 MI


BEST TRACK
TYPHOON KATE
14-25 OCT 1970
CYCLONE 22
6 HR BEST TRACK POSITS
SPEED
INTENSITY
TYPHOON OR TROPICAL STORM
TROPICAL DEPRESSION
TROPICAL DISTURBANCE
TSINGTAO
SHANGHAI
TOKYO
HONG KONG
MANILA
SAIGON
OKINAWA
CHICHI JIMA
IWO JIMA
ULITHI
YAP
KOROR
WOLEAI ATOL
TRUK
PONAPE
FUMATAHACHI
14/05Z
14/23Z
15/23Z
16/23Z
17/23Z
18/23Z
19/23Z
20/23Z
21/23Z
22/23Z
23/23Z
24/23Z
25/11Z

3. TYPHOON KATE NARRATIVE

While Joan was making headway in the South China Sea, Kate appeared on the scene developing south of Yap and commencing on an unusually low latitude track.

The initial impulse that later became Kate first revealed itself on the Majuro upper air sounding in the Marshalls with winds showing a cyclonic shift in the 700 mb and 500 mb levels on October 7th. The perturbation continued westward but realigned along a lower latitude apparently in response to the building heights to the rear of Joan. The ITOS-1 picture on the 13th showed a marked flare up in convective activity as the system moved under considerable difluent flow generated by equatorward outflow from Typhoon Joan some 1,300 miles to the northeast.

An organized pattern of clouds was apparent 300 miles south of Yap the following day. By the time a reconnaissance aircraft reached the area the afternoon of the 15th, Kate was near typhoon intensity with a wall cloud in process of forming, a central pressure of 986 mb and winds estimated near 60 knots.

During its westward journey in the following 3 days the typhoon remained small but concentrated. Shifting course slightly northwest the afternoon of the 17th (Figure 5-21), the storm aimed for the Davao Gulf of Mindanao reaching super typhoon strength some 24 hours later. The following evening its center arrived ashore 30 miles south of Davao City being the second typhoon to strike the Philippines in 4 days. Evidence of the highly concentrated nature of Kate at this time could be testified to by Davao not reporting a wind higher than 25 knots! Over 5,000 houses and other structures were lost in the accompanying storm surge, heavy rains and flooding in Southern Mindanao. Kate proved to be the most costly typhoon of the season as she struck an area unaccustomed to the effects of tropical cyclones and where light housing materials are common. A total of 631 persons perished with an additional 284 still counted as missing. Damage estimates were close to 50 million dollars (U.S.) The death toll counted surpassed all other typhoons on record in the Philippines and ranked Kate as the greatest killer cyclone experienced by that country.

Once over the Sulu Sea the storm was surprisingly intact after passing through the mountainous terrain of Mindanao. Kate slowly regained strength reaching typhoon strength just before passage over Busuanga Island. The Talampolan U. S. Coast Gurad LORAN station on the island reported gusts to 76 knots and a barometer reading of 989.9 mb.

Kate swung to a northward heading paralleling the western Luzon coast and slowing in forward speed as she approached the

ridge line (Figure 5-22). As height rises to the north blocked any further advancement, she slowly turned on a westward course on the 22nd setting sights for the Indochina coastline. Increasing in forward speed to 10 knots, the storm started to weaken on its west southwesterly track. Kate arrived onshore on the 25th just south of DaNang reduced to tropical storm force and bringing gale winds to the coast. The DaNang airfield reported winds 40 knots gusting to 66 knots. The storm lost intensity and later dissipated inland over the plateau region.

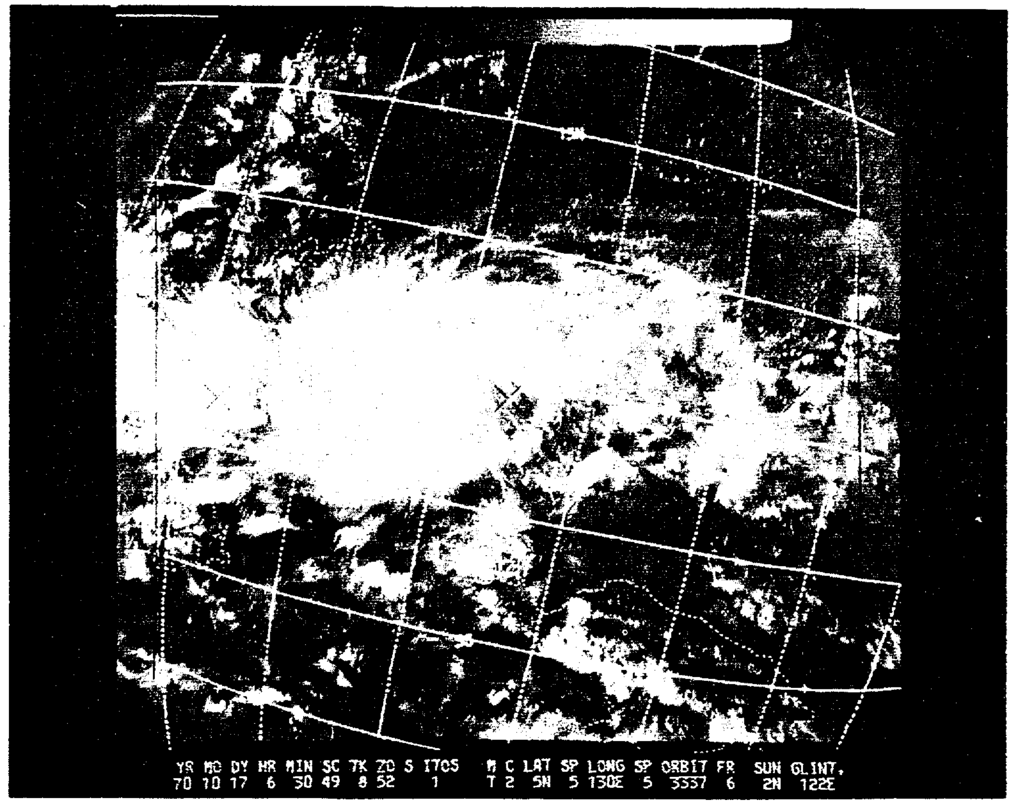


FIGURE 5-21 ITOS-1 DEPICTS TYPHOON KATE ON 17 OCTOBER DURING ITS LOW LATITUDE TRACK TOWARDS MINDANAO.

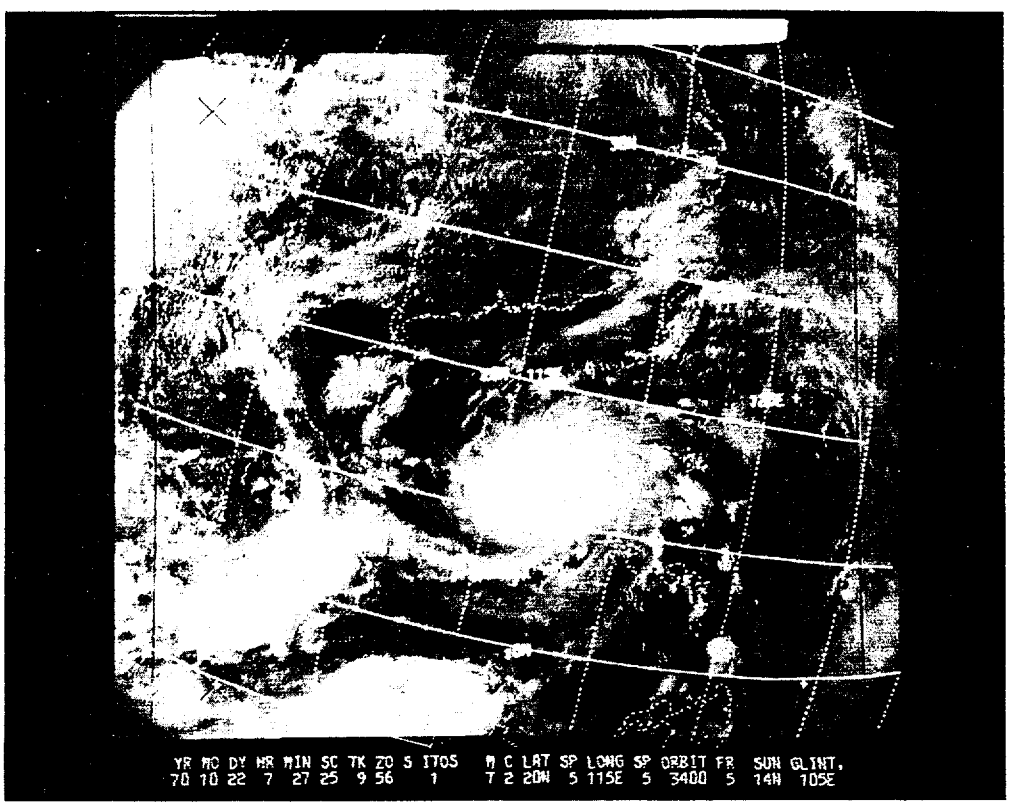


FIGURE 5-22 KATE WEST OF LUZON AS SEEN BY ITOS-1 ON 22 OCTOBER.

TYPHOON KATE

EYE FIXES CYCLONE 22

FIX NO.	TIME	POSIT	UNIT-METHOD-ACCY	FLT LVL	FLT LVL WND	OBS SFC WND	OBS MIN SLP	MIN 700MB HGT	FLT LVL TT/TD	EYE FORM	ORIEN-TATION	EYE DIA	CHARACTER WALL CLOUD
1	140536Z	05.0N 140.0E	SLTLS	STG B	DIA --	CAT -							----------
2	150555Z	04.5N 138.1E	54-P-06---	700MB	050	055	986	3018	19/14	----			W/C FORMG E-S
3	150633Z	04.0N 137.0E	SLTLS	STG B	DIA --	CAT -							----------
4	150737Z	04.3N 137.9E	54-P-06---	700MB	070	070	986	2984	16/11	----			W/C N-E-SE
5	151502Z	04.2N 136.8E	VW-P-05---		---	---	---	---	--/--	ELIP	NW-SE	30X17	7-10NM THK
6	152100Z	05.2N 135.7E	54-P-05---	700MB	075	075	976	2896	17/08	CIRC	----	25	CLSD, 10NM THK
7	160300Z	05.1N 134.8E	54-P-02---	700MB	075	085	971	2856	17/11	CIRC	----	20	CLSD, 10NM THK
8	160534Z	04.5N 133.5E	SLTLS	STG X	DIA 04	CAT 3							--------
9	161210Z	04.6N 132.3E	VW-P-05---		110	095	960	---	27/23	CIRC	----	17	ROTATG RAPIDLY
10	161405Z	04.7N 132.0E	VW-P------	700MB	---	---	959	2746	23/09	ELIP	N-S	15X13	10-12NM THK
11	161445Z	04.7N 131.9E	VW--------		---	---	---	---	--/--	----			----------
12	162100Z	04.5N 131.2E	54-P-05---	700MB	103	120	938	2591	23/13	CIRC	----	10	CLSD, 4NM THK
13	170300Z	04.4N 130.3E	54-P-10---	700MB	104	100	938	2600	27/11	CIRC	----	10	CLSD, 3-4NM THK
14	170631Z	04.7N 129.7E	SLTLS	STG X	DIA 03	CAT 4							----------
15	170830Z	04.8N 129.5E	VW-P-15---	0300M	---	050	---	---	--/--	ELIP	NW-SE	12X10	CLSD, 10-12NM THK
16	172100Z	05.3N 127.9E	54-P-08---	700MB	120	---	949	2664	21/09	CIRC	----	20	CLSD, 4-5NM THK
17	180300Z	05.9N 126.6E	54-P-05---	700MB	075	130	941	2621	23/11	CIRC	----	20	CLSD, 7NM THK
18	180727Z	06.0N 125.0E	SLTLS	STG X	DIA 05	CAT 3							------
19	180900Z	06.4N 125.8E	VW-P-10---	0300M	---	---	---	---	--/--	----			CLSD, BUT BRKG UP
20	181200Z	06.8N 125.3E	VW-P-20---		---	---	---	---	--/--	----			BARELY DISCRNBL
21	181418Z	07.2N 124.9E	VW-P-20---		---	---	---	---	--/--	----			APRNT W/C N QUAD
22	182100Z	07.2N 123.6E	54-P-05---	500MB	030	---	---	---	-3/-8	CIRC	----	04	NEG W/C
23	190040Z	11.6N 119.9E	LND RDR		---	---	---	---	--/--	----			----------
24	190140Z	11.9N 119.7E	LND RDR		---	---	---	---	--/--	----			----------
25	190300Z	09.1N 123.0E	54-P-10---	500MB	045	---	---	---	-2/-5	CIRC	----	10	NEG W/C
26	190600Z	09.8N 122.5E	54-P-20---	500MB	045	---	---	---	-4/-6	----			NEG W/C
27	190628Z	10.0N 121.5E	SLTLS	STG X	DIA 0	CAT 2							----------
28	190851Z	09.7N 122.1E	VW-P-05---	0300M	---	065	992	---	25/22	CIRC	----	14	CLSD
29	191152Z	10.1N 121.5E	VW-P-05---	0360M	---	065	988	---	25/22	CIRC	----	25	CLSD, WK S QUAD
30	191515Z	10.4N 121.1E	VW-P-05---	700MB	060	---	---	---	18/12	CIRC	----	20	CLSD
31	192100Z	11.5N 120.9E	54-P-02---	700MB	040	---	978	2905	18/12	CIRC	----	10	CLSD, 7NM THK
32	192340Z	11.7N 120.0E	LND RDR		---	---	---	---	--/--	----			----------
33	200000Z	11.8N 120.1E	54-P-02---	700MB	050	060	980	2908	16/12	CIRC	----	10	CLSD
34	200300Z	12.0N 119.5E	54-P-02---	700MB	040	070	976	2877	18/12	CIRC	----	15	CLSD, 5NM THK
35	200600Z	12.3N 119.2E	54-P-02---	700MB	050	090	972	2853	17/10	CIRC	----	10	CLSD
36	200721Z	12.5N 119.2E	SLTLS	STG X	DIA 02	CAT 4							----------
37	200900Z	12.7N 119.3E	VW-P-05---		---	---	---	---	--/--	CIRC	----	12	7NM THK, OPEN SW
38	201200Z	12.9N 119.0E	VW-P-05---		---	---	---	---	--/--	CIRC	----	16	5NM THK, OPEN SW
39	201447Z	13.2N 118.6E	VW-P-05---		---	---	---	---	--/--	CIRC	----	13	7NM THK, OPEN SW
40	201500Z	13.2N 118.7E	LND RDR		---	---	---	---	--/--	CIRC	----	40	----------
41	201530Z	13.4N 118.9E	LND RDR		---	---	---	---	--/--	CIRC	----	30	----------
42	202100Z	14.0N 118.4E	54-P-01---	700MB	065	---	958	2755	22/12	CIRC	----	07	8-10NM THK, OPEN S QUAD
43	210000Z	14.5N 118.2E	LND RDR		---	---	---	---	--/--	----			----------
44	210310Z	14.8N 118.0E	54-P-01---	700MB	070	125	958	2737	21/10	CIRC	----	15	5-8NM THK, OPEN SE
45	210631Z	14.7N 117.5E	SLTLS	STG X	DIA 0	CAT 3							----------
46	210845Z	15.3N 117.8E	VW-P-05---	0500M	110	115	961	---	27/23	CIRC	----	20	CLSD
47	211517Z	15.8N 117.5E	VW-P-05---	700MB	097	---	960	2781	18/10	CIRC	----	20	CLSD, WK SE QUAD
48	212100Z	16.1N 117.5E	54-P-05---	700MB	100	---	952	2698	18/11	ELIP	NW-SE	20X--	CLSD, 6NM THK

TYPHOON KATE

EYE FIXES CYCLONE 22

FIX NO.	TIME	POSIT	UNIT-METHOD-ACCY	FLT LVL	FLT LVL WND	OBS SFC WND	OBS MIN SLP	MIN 700MB HGT	FLT LVL TT/10	EYE FORM	ORIEN-TATION	EYE DIA	CHARACTER WALL CLOUD
49	220315Z	16.4N 117.1E	54-P-02---	700MB	090	---	953	2701	16/09	CIRC	----	20	6NM THK, WK SE
50	220727Z	16.0N 117.0E	SLTLS	STG X	DIA 04	CAT 4							----------
51	220805Z	16.6N 116.8E	VW-P-05---	0500M	115	115	947	---	23/20	ELIP	N-S	19X17	CLSD, 7NM THK, WK SE
52	221200Z	16.8N 116.4E	VW-P-12---		---	---	---	---	--/--	CIRC	----	17	CLSD, 7NM THK
53	221407Z	16.7N 116.5E	VW-P-12---		---	---	---	---	--/--	CIRC	----	17	CLSD, 7NM THK
54	222100Z	16.5N 116.2E	54-P-05---	700MB	105	---	941	2554	17/11	CIRC	----	17	CLSD, 5-7NM THK, WK SE
55	230315Z	15.7N 115.7E	54-P-02---	700MB	110	100	956	2707	16/12	CIRC	----	18	CLSD, 4NM THK
56	230600Z	16.7N 115.4E	54-P-02---	700MB	110	100	955	2698	16/12	CIRC	----	18	CLSD, 4NM THK
57	230629Z	16.5N 114.8E	SLTLS	STG X	DIA 03	CAT 4							----------
58	230910Z	16.5N 115.1E	VW-P-05---		125	125	950	---	22/24	CIRC	----	20	CLSD, 5-18NM THK
59	231130Z	16.5N 114.6E	VW-P-05---	700MB	105	---	952	2722	19/10	CIRC	----	20	CLSD, HVY S QUAD
60	231445Z	16.4N 114.1E	VW-P-05---	700MB	110	---	955	2777	19/11	CIRC	----	20	CLSD, 10NM THK
61	232100Z	16.1N 113.0E	54-P-02---	700MB	080	---	968	2822	13/10	ELIP	NE-SW	24X16	DEGENRTG, OPEN NW
62	240252Z	16.0N 112.0E	54-P-02---	700MB	070	065	991	2905	17/10	CIRC	----	30	WK W/C S QUAD
63	240725Z	16.0N 111.1E	SLTLS	STG X	DIA 03	CAT 3							----------
64	240855Z	15.9N 111.2E	VW-P-02---		---	060	---	---	--/--	CIRC	----	24	8NM THK, OPEN NW-NE
65	240910Z	15.9N 112.0E	LND RDR		---	---	---	---	--/--	----			----------
66	241045Z	15.9N 111.7E	LND RDR		---	---	---	---	--/--	----			----------
67	241157Z	15.6N 110.2E	VW-P-02---		---	---	---	---	--/--	CIRC	----	25	OPEN NNW-N-E-SE
68	241527Z	15.9N 110.3E	VW-P-05---	0500M	070	060	988	---	24/23	----			NEG W/C
69	241545Z	15.9N 109.6E	LND RDR		---	---	---	---	--/--	----			----------
70	242100Z	15.9N 109.5E	54-P-05---	700MB	050	---	989	2981	12/12	----			----------
71	250300Z	15.7N 108.4E	54-P-02---	500MB	055	---	995	---	-1/-5	CIRC	----	28	APRNT W/C W-N-SE

TYPHOON KATE

TROPICAL CYCLONE 22 -- 10/14/0500Z TO 10/25/1100Z
POSITION AND FORECAST VERIFICATION DATA

WARN NO.	DTG	WARNING POSIT LAT	WARNING POSIT LONG	BEST TRACK LAT	BEST TRACK LONG	24 HR FCST LAT	24 HR FCST LONG	24 HR ERROR DEG DIST	48 HR FCST LAT	48 HR FCST LONG	48 HR ERROR DEG DIST	72 HR FCST LAT	72 HR FCST LONG	72 HR ERROR DEG DIST
01	15/0500Z	4.4N	138.2E	4.4N	138.1E	5.6N	136.1E	066-0144	7.2N	132.8E	046-0228	-----	------	--------
02	15/1100Z	4.6N	137.6E	4.3N	137.4E	5.9N	135.3E	064-0174	7.4N	132.0E	044-0228	8.7N	128.2E	054-0198
03	15/1700Z	4.2N	136.6E	4.7N	136.5E	4.9N	133.5E	078-0108	6.5N	130.3E	049-0144	-----	------	--------
04	15/2300Z	5.4N	135.3E	5.1N	135.2E	8.3N	131.5E	011-0234	10.3N	128.1E	007-0300	12.0N	124.4E	016-0228
05	16/0500Z	5.3N	134.5E	4.6N	133.8E	6.9N	131.1E	023-0156	8.7N	128.0E	031-0186	-----	------	--------
06	16/1100Z	4.6N	132.5E	4.6N	132.6E	5.6N	127.7E	305-0102	6.5N	123.4E	264-0114	7.5N	119.6E	220-0186
07	16/1700Z	4.7N	131.5E	4.5N	131.6E	5.7N	127.2E	306-0078	6.6N	123.3E	229-0078	-----	------	--------
08	16/2300Z	4.5N	130.8E	4.4N	130.7E	4.9N	127.5E	165-0024	5.7N	124.8E	151-0174	6.7N	122.2E	160-0318
09	17/0500Z	4.5N	130.0E	4.5N	130.0E	5.0N	126.8E	158-0060	5.9N	124.2E	153-0228	-----	------	--------
10	17/1100Z	4.8N	129.1E	4.6N	129.2E	5.6N	125.9E	160-0066	6.6N	123.4E	154-0216	7.8N	120.8E	159-0312
11	17/1700Z	5.0N	128.0E	4.9N	128.4E	5.9N	124.9E	165-0096	7.1N	122.4E	160-0234	-----	------	--------
12	17/2300Z	5.3N	127.7E	5.3N	127.4E	6.2N	124.6E	150-0144	7.3N	121.5E	165-0270	8.8N	118.7E	176-0318
13	18/0500Z	6.0N	126.3E	6.0N	126.3E	7.5N	122.5E	176-0108	9.4N	118.9E	189-0162	-----	------	--------
14	18/1100Z	6.5N	125.4E	6.7N	125.4E	8.5N	121.4E	189-0084	10.8N	117.7E	211-0126	13.3N	114.3E	238-0234
15	18/1700Z	7.1N	124.3E	7.5N	124.4E	9.3N	120.5E	195-0090	11.7N	117.0E	220-0132	-----	------	--------
16	18/2300Z	7.6N	123.4E	8.3N	123.3E	9.9N	119.5E	202-0114	12.4N	116.0E	233-0162	15.0N	112.9E	253-0258
17	19/0500Z	9.3N	122.6E	9.3N	122.4E	12.8N	119.2E	351-0042	14.7N	115.6E	268-0132	-----	------	--------
18	19/1100Z	10.1N	121.8E	9.9N	121.7E	13.5N	118.3E	327-0054	15.8N	114.9E	278-0162	19.1N	113.2E	309-0246
19	19/1700Z	10.8N	120.7E	10.8N	121.0E	13.4N	116.8E	270-0096	16.1N	113.8E	273-0210	-----	------	--------
20	19/2300Z	11.6N	120.6E	11.7N	120.3E	14.5N	117.5E	299-0048	17.4N	115.3E	300-0126	20.2N	114.8E	344-0216
21	20/0500Z	12.4N	119.5E	12.1N	119.4E	15.1N	116.9E	288-0054	16.7N	115.7E	284-0072	-----	------	--------
22	20/1100Z	12.9N	119.1E	12.7N	118.9E	15.5N	117.3E	284-0024	17.3N	116.4E	352-0048	19.2N	115.8E	019-0168
23	20/1700Z	13.5N	118.5E	13.4N	118.5E	15.0N	117.0E	256-0024	17.7N	116.2E	360-0066	-----	------	--------
24	20/2300Z	14.1N	118.1E	14.1N	118.3E	16.6N	116.7E	300-0030	18.5N	116.0E	004-0108	20.5N	115.6E	032-0306
25	21/0500Z	15.0N	117.8E	14.8N	117.9E	17.8N	117.1E	005-0084	19.9N	116.9E	023-0204	-----	------	--------
26	21/1100Z	15.5N	117.7E	15.4N	117.8E	17.9N	117.1E	016-0084	19.9N	116.9E	031-0234	21.4N	116.8E	046-0468
27	21/1700Z	16.0N	117.5E	15.9N	117.5E	17.9N	117.1E	029-0084	19.5N	116.9E	043-0258	-----	------	--------
28	21/2300Z	16.2N	117.5E	16.3N	117.3E	17.8N	117.1E	046-0090	19.5N	116.9E	050-0312	21.0N	116.8E	005-0528
29	22/0500Z	16.5N	117.0E	16.4N	117.0E	18.1N	116.4E	030-0096	19.8N	116.2E	048-0336	-----	------	--------
30	22/1100Z	16.8N	116.7E	16.5N	116.6E	18.1N	115.6E	024-0102	19.6N	115.0E	048-0324	21.1N	114.6E	--------
31	22/1700Z	16.8N	116.3E	16.6N	116.3E	17.8N	115.0E	037-0108	19.2N	114.1E	050-0306	-----	------	--------
32	22/2300Z	16.5N	116.2E	16.7N	115.9E	16.8N	116.0E	078-0186	17.4N	114.4E	072-0306	18.0N	112.4E	--------
33	23/0500Z	16.8N	115.5E	16.5N	114.8E	17.3N	113.2E	048-0114	18.1N	110.3E	039-0180	-----	------	--------
34	23/1100Z	16.5N	114.9E	16.3N	113.8E	16.1N	112.3E	082-0084	15.9N	109.0E	--------	-----	------	--------
35	23/1700Z	16.4N	113.8E	16.1N	112.7E	16.0N	110.2E	064-0012	15.9N	106.2E	--------	-----	------	--------
36	23/2300Z	16.1N	112.6E	16.0N	111.7E	15.8N	108.1E	270-0060	-----	------	--------	-----	------	--------
37	24/0500Z	16.0N	111.6E	16.0N	111.7E	15.8N	107.2E	275-0060	-----	------	--------	-----	------	--------
38	24/1100Z	15.9N	110.9E	15.9N	110.8E	15.8N	106.7E	--------	-----	------	--------	-----	------	--------
39	24/1700Z	15.9N	110.1E	15.9N	110.0E	15.8N	106.4E	--------	-----	------	--------	-----	------	--------
40	24/2300Z	15.9N	109.2E	15.8N	109.2E	-----	------	--------	-----	------	--------	-----	------	--------
41	25/0500Z	15.9N	108.2E	15.7N	108.3E	-----	------	--------	-----	------	--------	-----	------	--------
42	25/1100Z	16.0N	107.3E	-----	------	-----	------	--------	-----	------	--------	-----	------	--------

AVERAGE 24 HOUR ERROR - 0089 MI.
AVERAGE 48 HOUR ERROR - 0192 MI.
AVERAGE 72 HOUR ERROR - 0284 MI.

L. TYPHOON PATSY 14 NOV 0500Z-22 NOV 0500Z

1. STATISTICS

   a. Number of Warnings Issued - 33

   b. Number of Warnings with Typhoon Intensity - 19

   c. Distance Traveled During Warning Period - 2,917 MI

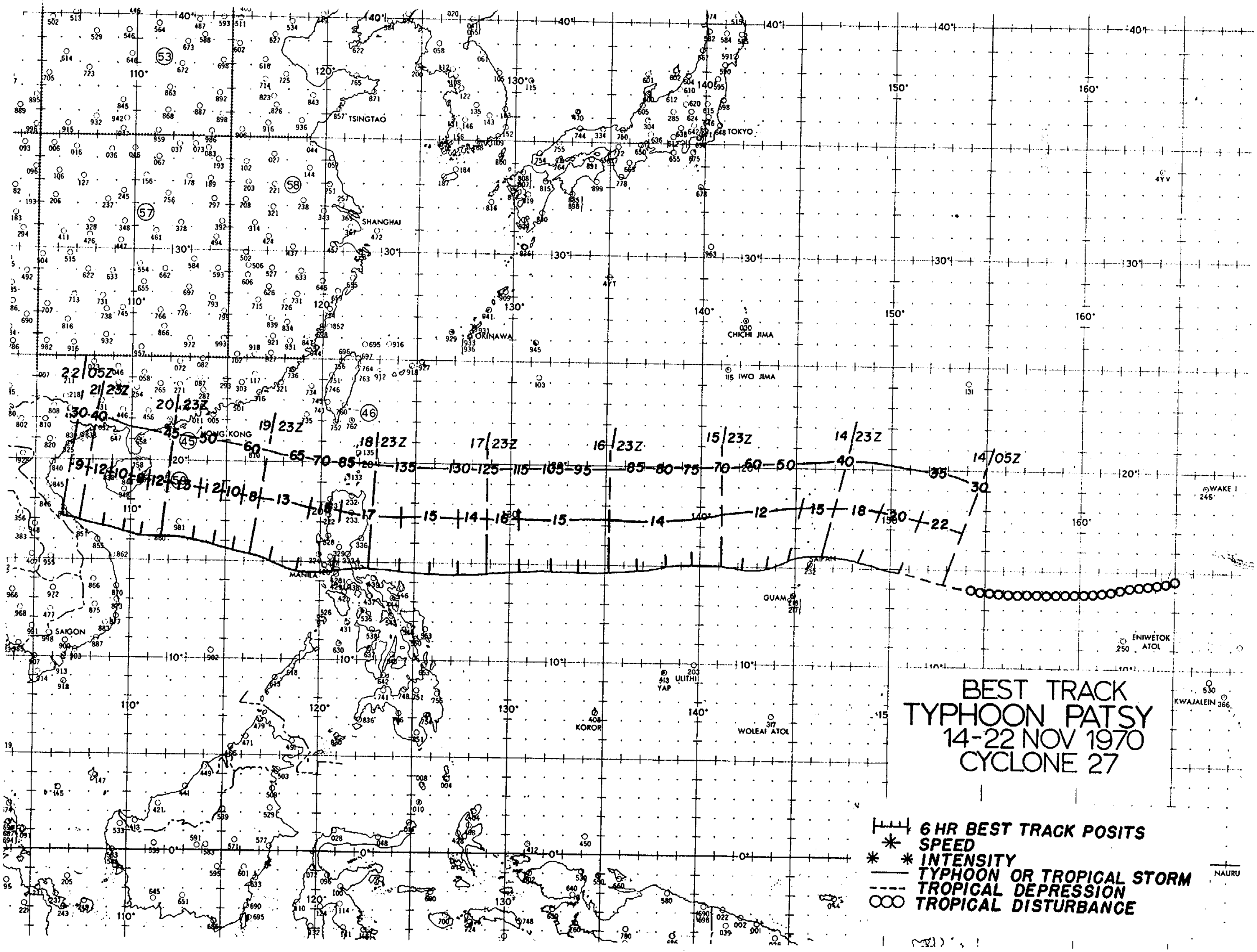
2. CHARACTERISTICS AS A TYPHOON

   a. Minimum Observed SLP - 918 MBS at 18/2200Z

   b. Minimum Observed 700 MB Height - 2256 M at 18/0957Z

   c. Maximum Surface Wind - 135 KTS (From Best Track)

   d. Maximum Radius of Surface Circulation - 600 MI


BEST TRACK
TYPHOON PATSY
14-22 NOV 1970
CYCLONE 27
6 HR BEST TRACK POSITS
SPEED
INTENSITY
TYPHOON OR TROPICAL STORM
TROPICAL DEPRESSION
TROPICAL DISTURBANCE
TSINGTAO
SHANGHAI
HONG KONG
MANILA
SAIGON
TOKYO
OKINAWA
CHICHI JIMA
IWO JIMA
SAIPAN
GUAM
ULITHI
YAP
KOROR
WOLEAI ATOL
ENIWETOK ATOL
KWAJALEIN
WAKE I
NAURU

3. TYPHOON PATSY NARRATIVE

Culminating a light typhoon season, Patsy showed herself in embroyonic form as a disturbance southeast of Wake Island on the 10th of November. Associated with an upper level circulation in the Mid-Pacific trough the system tracked slightly south of west for three days gradually reflecting downward to the surface as a wave trough.

By the 13th satellite photographs from the ESSA-8 and ITOS-1 indicated further development was in process as cloudiness was taking on a more organized character. However, reconnaissance aircraft could locate no closed circulation at the surface, as the speed of translation (22 knots) of the system and the presence of a 200 mb shearline to its north apparently inhibited further intensification.

During the early morning hours of the 14th a surface depression formed just east of the Marianas' chain. Patsy was at the threshold of tropical storm strength as she slowed in forward speed to 12 knots and passed just north of Saipan near noon. The U. S. Coast Guard station on the island indicated a barometer dip to 999 mb and gusts to 30 knots in thunderstorms. (See Figure 5-23 for satellite view sequence of Patsy.)

As development was occurring practically in the backyard of the Joint Typhoon Warning Center on Guam, the opportunity presented itself to view by radar the transformations that were taking place. The FPS-81 (5cm) collocated at Fleet Weather Central began to detect spiral band activity in the afternoon and later indications of a developing eye, as the storm started to move out of range. A reconnaissance aircraft confirmed the following morning that Patsy had attained typhoon force 200 miles west northwest of Guam.

For the next four days, a strong ridge line prevented any meridianal component to the typhoon's westward movement at 14 to 15 knots. Luzon now became the target of a third typhoon in as many months.

Approaching the southeastern periphery of a 200 mb anticyclone centered near the Luzon straits, Patsy began a steady reduction in central pressure on the morning of the 17th which increased her maximum winds to super typhoon strength by the following afternoon. Near daybreak on the 19th, a reconnaissance aircraft at 500 mb fixed the 20 mile diameter eye in Luzon's Lamon Bay 105 miles east of Manila. The winds were estimated near 135 knots while a dropsonde reading indicated deepening had bottomed out at 918 mb.

A few hours earlier, the center had passed 40 miles north of the U. S. Coast Guard station on Catanduanes Island. Westerly winds of 90 knots with gusts to 100 knots were experienced while the barometer showed a reading of 975.7 mb.

Arriving ashore by mid-morning Patsy showed little slowdown in forward speed as she roared through the metropolitan area of Manila creating considerable havoc. Calms of varying times up to 35 minutes were reported during her high noon passage. Not since Winnie in June of 1964 had a typhoon so seriously affected the city of Manila.

During the siege the President Taft was torn from its anchorage and collided with the Greek vessel Aliakmon in Manila Bay while the coastal freighter PMI Engineer and a passenger ship of the Philippine President Lines were blown aground.

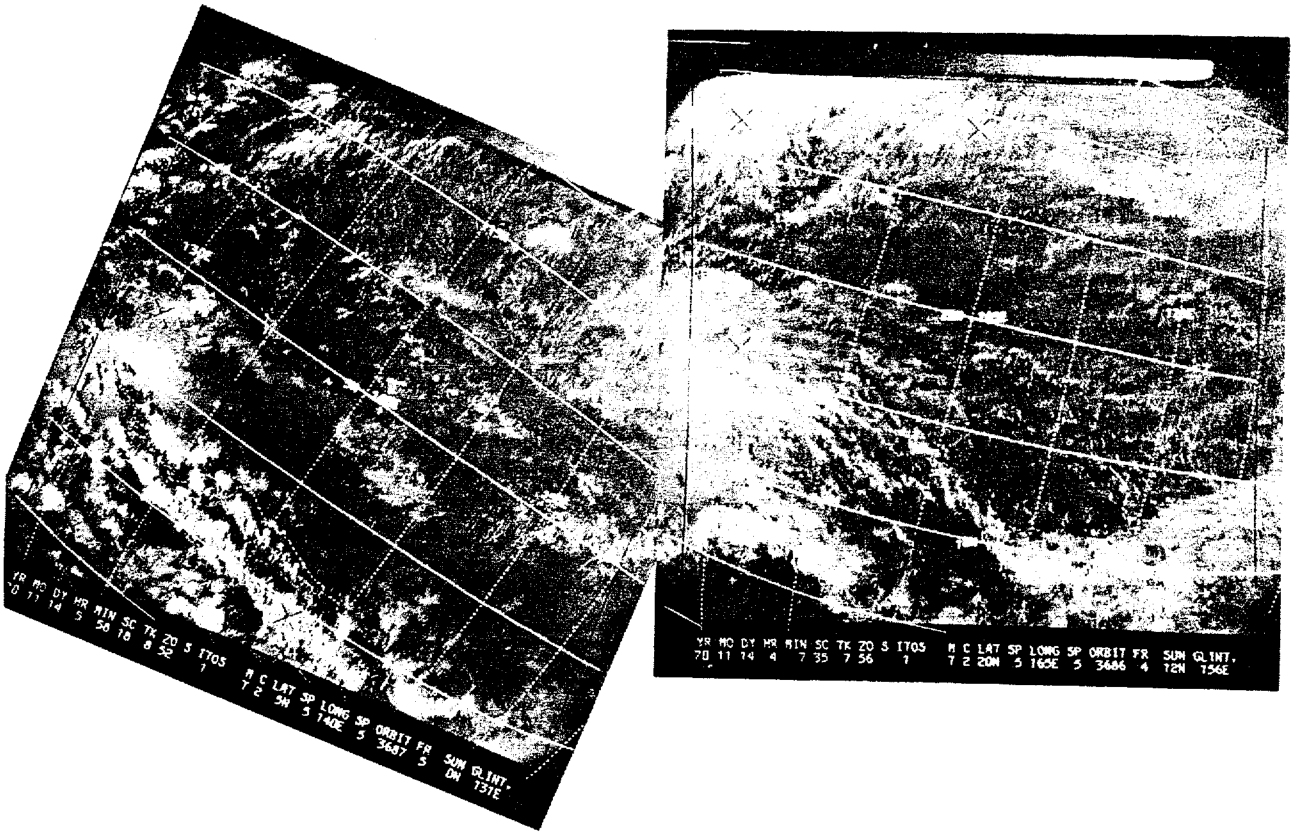
Manila International Airport reported a peak gust to 108 knots with the lowest reported pressure 969.3 mb. Both the Naval Station at Sangley Point on Manila Bay and Naval Air Station at Cubi Point on Subic Bay recorded gusts to 78 knots as Patsy's center passed within 10 miles.

The storm was responsible for 241 deaths and 1,756 injured with an additional 351 reported missing. At least 135 of the deaths occurred at sea. The damage toll incurred was near 80 million dollars (U.S.) as there were an estimated 31,380 refugees in Manila alone whose homes were completely or partially destroyed. Patsy stands on record as the most devastating to strike Manila, since the establishment of the Philippine Weather Bureau in 1865.

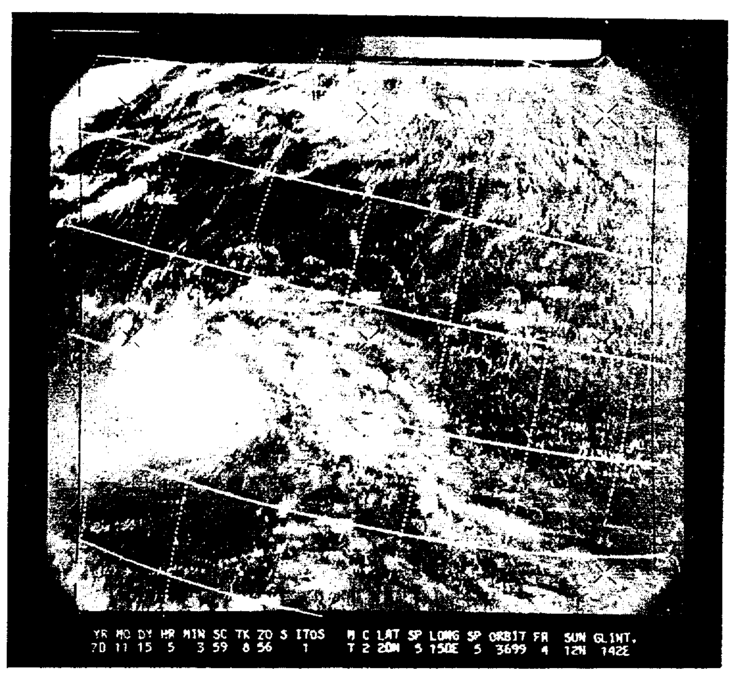
Leaving Luzon, the organized structure of the typhoon had been disrupted by her transit over the rugged islands. Patsy later weakened to tropical storm strength as she moved further into the South China Sea on the 19th. The cooler water and the modifying effect of the northeast monsoon acted as a barrier to any reintensification.

As a small high cell in the Gulf of Tonkin began to give way to a trough in the westerlies, the course of the storm shifted north of west which brought the center inland near the 17th parallel of the Indochina coastline on the 22nd. Quang Tri, just south of where the center struck, reported winds of 35 knots and gusts to 47 knots. Shortly afterwards the circulation broke up and dissipated over the highland region.

FIGURE 5-23 ITOS-1 VIEW SEQUENCE OF TYPHOON PATSY

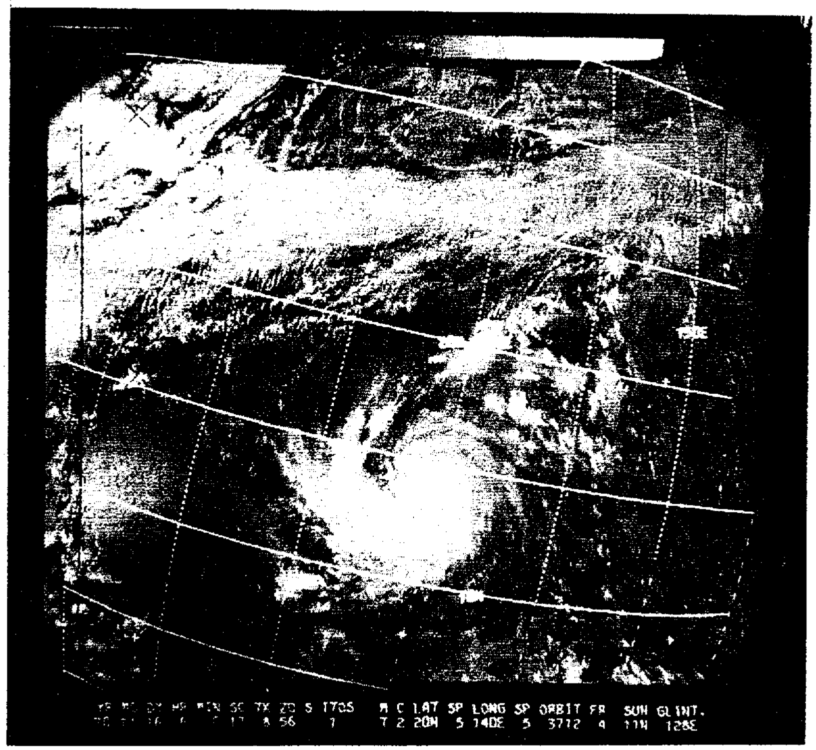


14 NOVEMBER - WAVE STAGE

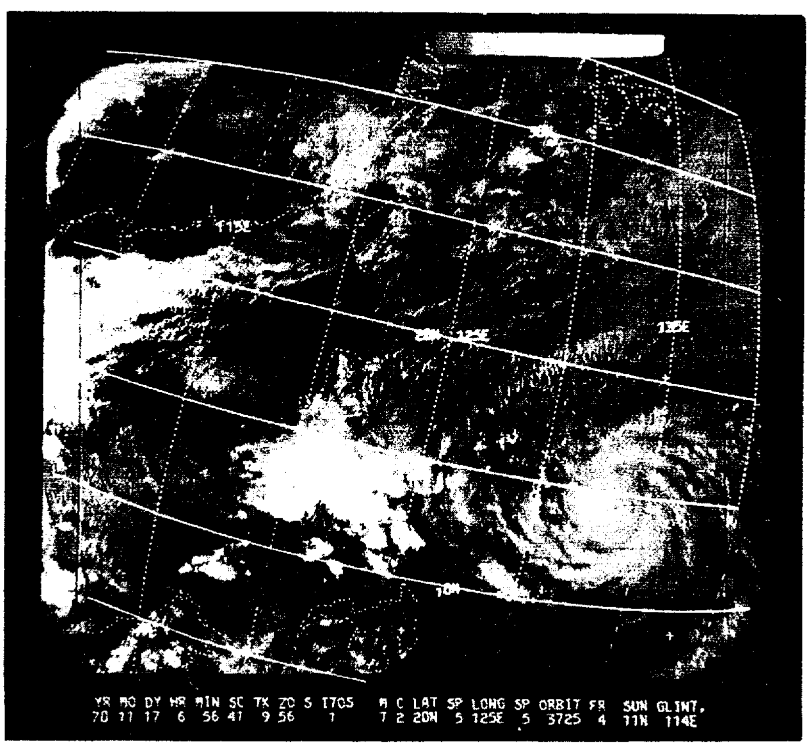


15 NOVEMBER - TROPICAL STORM STAGE

FIGURE 5-23 (CONT.) ITOS-1 VIEW SEQUENCE OF TYPHOON PATSY

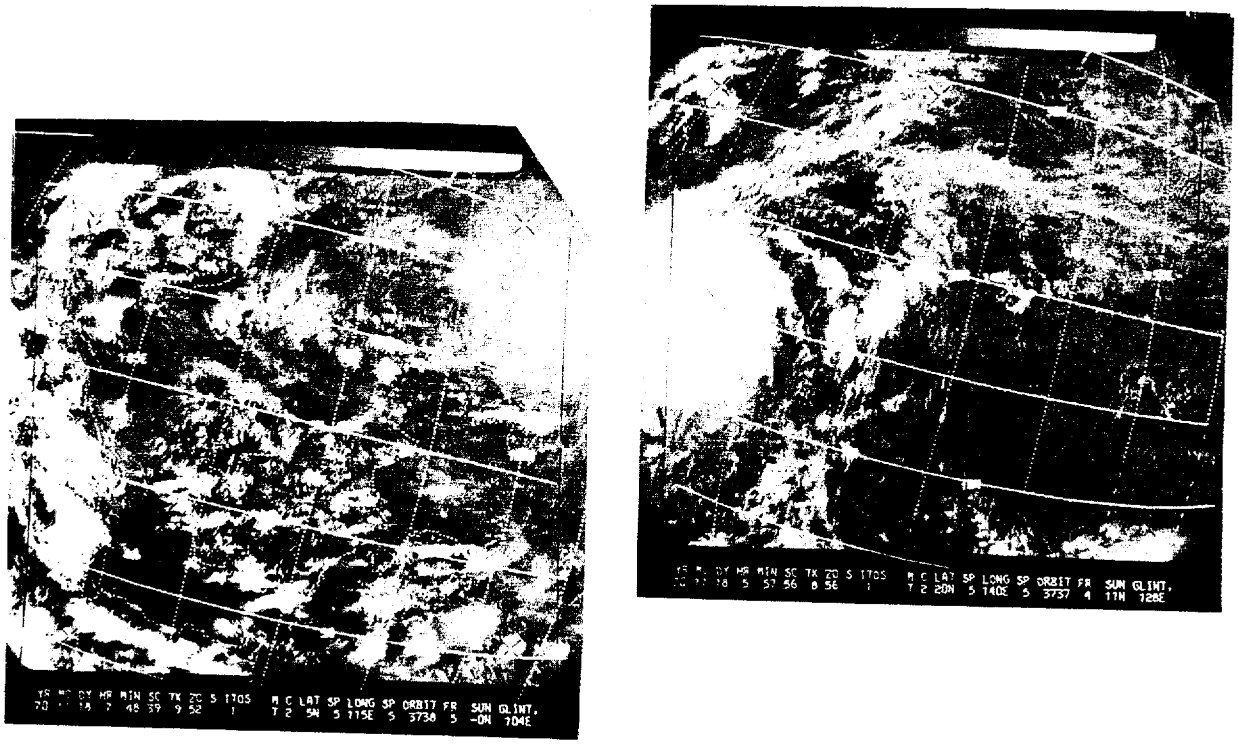


16 NOVEMBER - TYPHOON STRENGTH (75 KT)

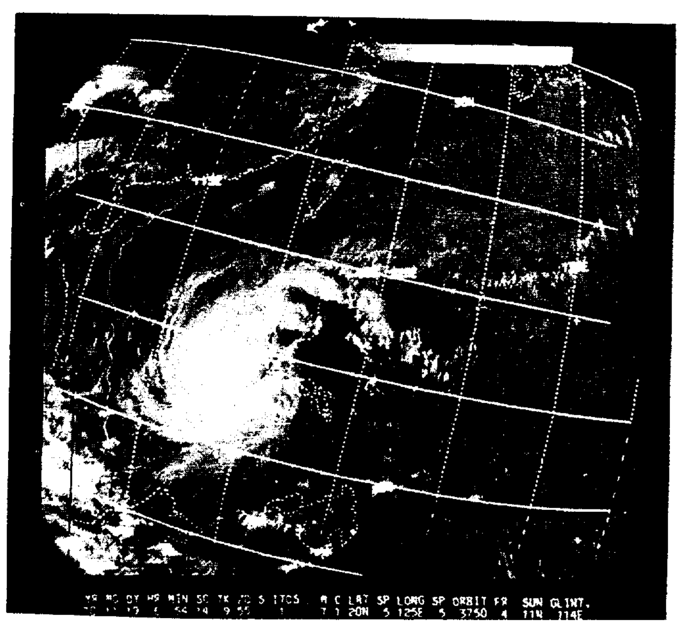


17 NOVEMBER - TYPHOON STRENGTH (95 KT)

FIGURE 5-23 (CONT.) ITOS-1 VIEW SEQUENCE OF TYPHOON PATSY



18 NOVEMBER - SUPER TYPHOON STRENGTH (130 KT)



19 NOVEMBER - TYPHOON STRENGTH (80 KT) - WEAKENED AFTER TRAVERSE OF LUZON.

TYPHOON PATSY

EYE FIXES CYCLONE 27

FIX NO.	TIME	POSIT	UNIT-METHOD-ACCY	FLT LVL	FLT LVL WND	OBS SFC WND	OBS MIN SLP	MIN 700MB HGT	FLT LVL TT/TO	EYE FORM	ORIEN-TATION	EYE DIA	CHARACTER WALL CLOUD
1	130506Z	13.0N 159.6E	SLTLS	STG B	DIA --	CAT -							----------
2	140408Z	13.5N 153.0E	SLTLS	STG X	DIA 03	CAT 2							----------
3	141030Z	14.7N 150.4E	VW-P-20---	0500M	---	028	006	---	25/26	----			----------
4	142030Z	15.3N 147.4E	54-P-05---	700MB	035	040	995	3082	12/11	----			NEG W/C
5	150030Z	15.4N 146.0E	54-P-02---	700MB	---	040	998	3088	14/13	----			W/C DEVLPG SE QUAD
6	150315Z	15.3N 145.3E	54-P-05---	700MB	---	040	998	3075	16/14	----			W/C DEVLPG SE QUAD
7	150504Z	14.5N 145.0E	SLTLS	STG X	DIA 05	CAT 3							----------
8	150633Z	15.0N 144.4E	LND RDR		---	---	---	---	--/--	----			----------
9	150836Z	15.0N 144.2E	VW-P-06---		---	---	---	---	--/--	CIRC	----	17	WK W/C S-W-NW
10	150945Z	15.0N 144.0E	LND RDR		---	---	---	---	--/--	----			----------
11	151245Z	14.6N 143.6E	LND RDR		---	---	---	---	--/--	----			----------
12	151500Z	14.9N 142.9E	LND RDR		---	---	---	---	--/--	----			----------
13	151518Z	14.8N 143.2E	VW-P-10---		---	---	---	---	--/--	CIRC	----	20	7NM THK, OPEN W
14	152100Z	15.0N 141.6E	54-P-05---	700MB	040	065	986	3021	16/12	CIRC	----	18	CLSD
15	160000Z	15.1N 140.8E	54-P-05---	700MB	070	080	990	3018	15/11	CIRC	----	15	CLSD
16	160300Z	14.9N 140.0E	54-P-05---	700MB	067	090	989	3008	15/11	CIRC	----	10	CLSD
17	160600Z	14.6N 139.3E	SLTLS	STG X	DIA 03	CAT 3							----------
18	160759Z	15.3N 138.5E	ACFT RDR		---	---	---	---	--/--	----			----------
19	161018Z	15.0N 138.3E	VW-P-05---		---	030	---	---	--/--	ELIP	NE-SW	36X17	INTENSE SE & W
20	161450Z	14.8N 137.6E	VW-P-10---	700MB	---	---	---	2957	19/11	ELIP	NW-SE	12X10	OPEN NW
21	162100Z	14.6N 135.7E	54-P-07---	700MB	060	070	972	2853	16/12	ELIP	NW-SE	18X09	BRKN NRN HALF
22	170300Z	14.7N 134.5E	54-P-05---	700MB	070	080	961	2755	18/12	ELIP	NW-SE	16X12	CLSD
23	170656Z	14.7N 133.5E	SLTLS	STG X	DIA 0[illegible]	CAT 3							----------
24	170903Z	14.4N 132.5E	VW-P-15---		---	---	---	---	--/--	ELIP	NW-SE	16X08	CLSD
25	171400Z	14.6N 131.5E	VW-P-05---	700MB	---	---	940	2582	17/12	ELIP	N-S	16X08	CLSD
26	172100Z	14.3N 129.2E	54-P-05---	700MB	102	---	930	2475	20/13	CONC		30-08	OUTER-CLSD, INNER-CLSD
27	180300Z	14.6N 127.9E	54-P-03---	700MB	080	120	922	2402	22/12	ELIP	NW-SE	25X15	CLSD, 5-8NM THK
28	180600Z	14.0N 127.0E	SLTLS	STG X	DIA 06	CAT 4							----------
29	180800Z	14.6N 127.1E	LND RDR		---	---	---	---	--/--	----			----------
30	180957Z	14.2N 126.6E	VW-P-05---	700MB	118	---	916	2256	26/11	CIRC	----	18	CLSD, 6-14NM THK
31	181336Z	14.6N 125.5E	LND RDR		---	---	---	---	--/--	----			----------
32	181436Z	14.6N 124.9E	LND RDR		---	---	---	---	--/--	----			----------
33	181517Z	14.5N 124.8E	VW-P-05---	700MB	080	---	---	---	--/--	CIRC	----	15	CLSD, 6-15NM THK
34	181536Z	14.6N 124.6E	LND RDR		---	---	---	---	--/--	----			----------
35	181636Z	14.8N 124.5E	LND RDR		---	---	---	---	--/--	----			----------
36	181736Z	14.8N 124.2E	LND RDR		---	---	---	---	--/--	----			----------
37	181836Z	14.8N 123.8E	LND RDR		---	---	---	---	--/--	----			----------
38	181936Z	14.6N 123.6E	LND RDR		---	---	---	---	--/--	----			----------
39	182040Z	14.7N 123.2E	LND RDR		---	---	---	---	--/--	----			----------
40	182200Z	14.5N 123.0E	54-P-03---	500MB	090	095	918	---	09/-5	CIRC	----	20	CLSD, 5-10NM THK
41	182210Z	14.7N 122.8E	LND RDR		---	---	---	---	--/--	----			----------
42	182340Z	14.7N 122.6E	LND RDR		---	---	---	---	--/--	----			----------
43	190100Z	14.6N 122.2E	54-P-01---	500MB	100	100	---	---	10/-6	CIRC	----	16	CLSD, 10NM THK
44	190115Z	14.7N 122.0E	LND RDR		---	---	---	---	--/--	----			----------
45	190140Z	14.8N 122.2E	LND RDR		---	---	---	---	--/--	----			----------
46	190208Z	14.9N 121.5E	LND RDR		---	---	---	---	--/--	----			----------
47	190225Z	14.8N 121.6E	LND RDR		---	---	---	---	--/--	----			----------
48	190240Z	14.8N 121.2E	LND RDR		---	---	---	---	--/--	----			----------

TYPHOON PATSY

EYE FIXES CYCLONE 27

FIX NO.	TIME	POSIT	UNIT-METHOD-ACCY	FLT LVL	FLT LVL WND	OBS SFC WND	OBS MIN SLP	MIN 700MB HGT	FLT LVL TT/TO	EYE FORM	ORIENTATION	EYE DIA	CHARACTER WALL CLOUD
49	190325Z	14.9N 121.2E	LND RDR		---	---	---	---	--/--	----			----------
50	190445Z	14.9N 120.6E	LND RDR		---	---	---	---	--/--	----			----------
51	190505Z	14.9N 120.6E	LND RDR		---	---	---	---	--/--	----			----------
52	190635Z	14.6N 120.5E	LND RDR		---	---	---	---	--/--	----			----------
53	190645Z	14.5N 119.8E	SLTLS	STG X	DIA 03		CAT 4						----------
54	190800Z	15.3N 119.4E	LND RDR		---	---	---	---	--/--	----			----------
55	190830Z	15.3N 119.2E	LND RDR		---	---	---	---	--/--	----			----------
56	190846Z	14.5N 119.8E	VW-R-10---		---	---	---	---	--/--	----			NEG W/C
57	190900Z	15.2N 118.6E	LND RDR		---	---	---	---	--/--	----			----------
58	191000Z	15.2N 118.6E	LND RDR		---	---	---	---	--/--	----			----------
59	191045Z	15.5N 118.4E	LND RDR		---	---	---	---	--/--	----			----------
60	191145Z	15.0N 118.2E	LND RDR		---	---	---	---	--/--	----			----------
61	191418Z	14.8N 118.1E	VW-P-02---	0300M	071	065	987	---	26/22	----			NEG W/C
62	192355Z	15.8N 115.5E	VW-R-02---		---	050	---	---	--/--	----			NO APRNT W/C
63	200200Z	15.4N 115.6E	VW-R-20---		045	045	---	---	--/--	----			FRMG W QUAD, 6NM THK
64	200300Z	15.4N 115.7E	54-R-15---		---	---	---	---	--/--	----			FORMD S-NW
65	200751Z	15.0N 114.0E	SLTLS	STG X	DIA 04		CAT 3						----------
66	200917Z	15.5N 114.3E	VW-R-15---		---	---	---	---	--/--	----			----------
67	200936Z	15.7N 115.0E	VW-P-05---	0500M	040	045	989	---	26/24	CIRC	----	30	OPEN N SEMICIR
68	201414Z	15.8N 113.9E	VW-P-03---	700MB	030	---	987	3042	19/12	----			NEG W/C
69	210300Z	15.9N 111.0E	54-P-05---	700MB	040	035	998	3037	13/11	CIRC	----	14	WK W/C OPEN S
70	210847Z	16.0N 109.5E	SLTLS	STG X	DIA 03		CAT 2						----------
71	210915Z	16.3N 109.7E	VW-P-05---	0400M	047	050	988	---	28/21	CIRC	----	10	NEG W/C
72	211152Z	16.3N 109.5E	VW-P-02---	0400M	043	045	996	---	26/23	CIRC	----	10	NEG W/C
73	211453Z	16.7N 108.8E	VW-P-03---	0400M	043	040	998	---	26/21	CIRC	----	10	NEG W/C

TYPHOON PATSY

TROPICAL CYCLONE 27 -- 11/14/0500Z TO 11/22/0500Z
POSITION AND FORECAST VERIFICATION DATA

WARN NO.	DTG	WARNING POSIT LAT	WARNING POSIT LONG	BEST TRACK LAT	BEST TRACK LONG	24 HR FCST LAT	24 HR FCST LONG	24 HR ERROR DEG DIST	48 HR FCST LAT	48 HR FCST LONG	48 HR ERROR DEG DIST	72 HR FCST LAT	72 HR FCST LONG	72 HR ERROR DEG DIST
01	14/0500Z	13.8N	152.7E	14.3N	152.8E	13.8N	146.0E	143-0108	14.9N	140.0E	108-0018	-----	------	---------
02	14/1100Z	13.7N	151.0E	14.8N	148.3E	13.9N	144.9E	129-0090	15.4N	138.4E	027-0024	16.0N	133.3E	041-0102
03	14/1700Z	13.8N	149.5E	15.2N	148.3E	14.2N	143.0E	144-0048	15.7N	137.1E	019-0054	-----	------	---------
04	14/2300Z	15.4N	146.5E	15.4N	146.4E	15.2N	139.5E	277-0090	16.0N	133.3E	305-0132	16.6N	128.3E	351-0126
05	15/0500Z	15.2N	144.7E	15.3N	144.8E	14.7N	138.2E	258-0078	15.0N	132.9E	293-0042	-----	------	---------
06	15/1100Z	14.9N	143.6E	14.9N	143.6E	14.0N	137.9E	186-0060	14.2N	132.8E	129-0042	15.1N	128.3E	077-0150
07	15/1700Z	14.7N	142.9E	14.9N	142.4E	14.1N	139.2E	106-0150	14.0N	135.1E	097-0264	-----	------	---------
08	15/2300Z	15.0N	141.1E	15.0N	141.1E	15.0N	135.3E	019-0018	14.7N	130.8E	085-0120	14.7N	126.7E	090-0246
09	16/0500Z	14.9N	139.5E	15.0N	139.6E	14.6N	133.8E	134-0006	14.7N	129.3E	084-0114	-----	------	---------
10	16/1100Z	15.0N	138.1E	15.0N	138.1E	14.9N	132.8E	072-0036	14.8N	128.6E	084-0168	14.6N	124.5E	090-0318
11	16/1700Z	14.8N	137.1E	14.8N	136.7E	14.8N	132.2E	083-0096	14.8N	128.0E	087-0216	-----	------	---------
12	16/2300Z	14.5N	135.2E	14.7N	135.2E	14.0N	129.5E	125-0048	14.3N	124.6E	100-0126	14.9N	120.5E	095-0240
13	17/0500Z	14.7N	134.0E	14.7N	133.7E	14.7N	128.4E	079-0060	15.2N	123.0E	075-0132	-----	------	---------
14	17/1100Z	14.5N	132.0E	14.7N	132.1E	14.7N	126.0E	046-0012	14.9N	121.1E	082-0120	15.1N	116.9E	104-0144
15	17/1700Z	14.5N	130.8E	14.6N	130.5E	14.8N	125.0E	075-0042	14.9N	120.1E	090-0144	-----	------	---------
16	17/2300Z	14.5N	128.7E	14.5N	12[illegible].7E	15.0N	122.5E	019-0018	14.9N	117.6E	108-0072	14.8N	113.5E	104-0096
17	18/0500Z	14.5N	127.4E	14.5N	127.3E	15.2N	121.3E	040-0042	15.2N	116.2E	119-0048	-----	------	---------
18	18/1100Z	14.4N	126.2E	14.5N	125.7E	15.2N	120.3E	064-0078	15.2N	115.4E	119-0060	15.2N	111.3E	126-0120
19	18/1700Z	14.5N	124.4E	14.6N	124.2E	15.2N	118.5E	070-0048	15.2N	113.5E	046-0012	-----	------	---------
20	18/2300Z	14.[illegible]N	122.8E	14.7N	122.4E	15.0N	116.8E	126-0030	15.1N	111.9E	134-0006	14.9N	107.8E	169-0126
21	19/0500Z	14.9N	121.1E	14.6N	120.7E	15.2N	115.1E	207-0024	15.0N	110.2E	189-0078	-----	------	---------
22	19/1100Z	14.6N	119.2E	14.6N	119.0E	14.7N	113.4E	222-0078	14.2N	109.4E	183-0132	-----	------	---------
23	19/1700Z	14.7N	117.4E	14.9N	117.6E	14.6N	111.7E	255-0084	13.3N	107.3E	200-0216	-----	------	---------
24	19/2300Z	14.7N	115.9E	15.3N	116.3E	14.3N	110.1E	241-0108	-----	------	---------	-----	------	---------
25	20/0500Z	15.2N	115.5E	15.6N	115.4E	14.7N	109.8E	201-0102	-----	------	---------	-----	------	---------
26	20/1100Z	15.7N	114.7E	15.7N	114.4E	16.1N	110.2E	120-0030	-----	------	---------	-----	------	---------
27	20/1700Z	15.8N	113.3E	15.0N	113.2E	15.4N	108.4E	185-0078	-----	------	---------	-----	------	---------
28	20/2300Z	15.9N	111.9E	15.2N	111.8E	-----	------	---------	-----	------	---------	-----	------	---------
29	21/0500Z	15.8N	110.5E	16.3N	110.5E	-----	------	---------	-----	------	---------	-----	------	---------
30	21/1100Z	16.3N	109.4E	16.4N	109.6E	-----	------	---------	-----	------	---------	-----	------	---------
31	21/1700Z	16.6N	108.5E	16.7N	108.6E	-----	------	---------	-----	------	---------	-----	------	---------
32	21/2300Z	16.8N	107.5E	17.0N	107.3E	-----	------	---------	-----	------	---------	-----	------	---------
33	22/0500Z	17.1N	106.4E	-----	------	-----	------	---------	-----	------	---------	-----	------	---------

AVERAGE 24 HOUR ERROR - 0061 MI.
AVERAGE 48 HOUR ERROR - 0101 MI.
AVERAGE 72 HOUR ERROR - 0166 MI.

REFERENCES:

Cressman, G. P., "Northward Acceleration of Typhoons," Bulletin of the American Meteorological Society Vol. 33, No. 6, June 1952, p 243.

Fett, R. F., "Typhoon Formation within the Zone of the Intertropical Convergence," Monthly Weather Review Vol. 96, No. 2, February 1968, pp106-117.

Jordan, C. L., "Reported Sea Level Pressure of 877 Mb," Monthly Weather Review Vol. 87, No. 9, September 1959, pp365-366.

Miller, B. I., "On the Maximum Intensity of Hurricanes," National Hurricane Research Project Report No. 14, U. S. Weather Bureau, Washington, D. C., December 1957, 19pp.

Simpson, R. H., A. L. Sugg, and Staff, "The Atlantic Hurricane Season of 1969," Monthly Weather Review Vol. 98, No. 4, April 1970, pp293-294 and p304.

Sugg, A. L., and Pelissier, J. M., "The Hurricane Season of 1967," Monthly Weather Review Vol. 96, No. 4, April 1968, p246.

DEFINITION OF TERMS AND ABBREVIATIONS IN CHAPTER 5

1. The units used in the tables and figures in this chapter are as follows:

DISTANCE - Nautical Miles/Speed Knots

HEIGHT OF PRESSURE LEVEL - Meters

PRESSURE - Millibars

TEMPERATURE - Degrees Celsius

2. With reference to eye fix data summaries, the following terms and abbreviations are used:

a. UNIT - Reconnaissance unit that made the fix.

54WRS = 54th Weather Reconnaissance Squadron

VW-1 = Airborne Early Warning Squadron ONE

b. METHOD

P = Penetration

R = Airborne Radar

SLTLS = Position Based on NESS Satellite Bulletins

LND RDR = Land Radar

ACFT RDR = Aircraft Radar (Commercial or Military) Other than 54 or VW

c. ACCY - Estimated navigational accuracy of the fix in nautical miles.

d. FLT LVL TT/TO - Flight level temperature inside/outside the eye or center.

e. CHARACTER WALL CLOUD - Extent to which the wall cloud encloses the eye and its thickness based on reconnaissance estimate. Remark as to its development may also appear under this heading.

Abbreviations used in CHARACTER WALL CLOUD columns follow:

ALQUADS	All quadrants
APRNT	Apparent
APRS	Appears
BLDG	Building
BRKG	Breaking
BRKN	Broken
BRKS	Breaks
CLSD	Closed
CONC	Concentric
DEF	Defined
DEGENRTG	Degenerating
DETERG	Deteriorating
DEVLPG	Developing
DIFF	Difficult
DISCRNBL	Discernable
DISORG	Disorganized
DISIPTG	Dissipating
FB	Feeder bands
FORMD	Formed
FORMG	Forming
HLF	Half
HVY	Heavy
IRREG	Irregular
NEG	Negative
ORG	Organized
PRESNT	Presentation
QUAD	Quadrant
REFORMG	Reforming
RDR	Radar
ROTATG	Rotating
SEMICIR	Semicircle
SEP	Separate
SML	Small
W/C	Wall cloud
WK	Weak

ANNEX

A

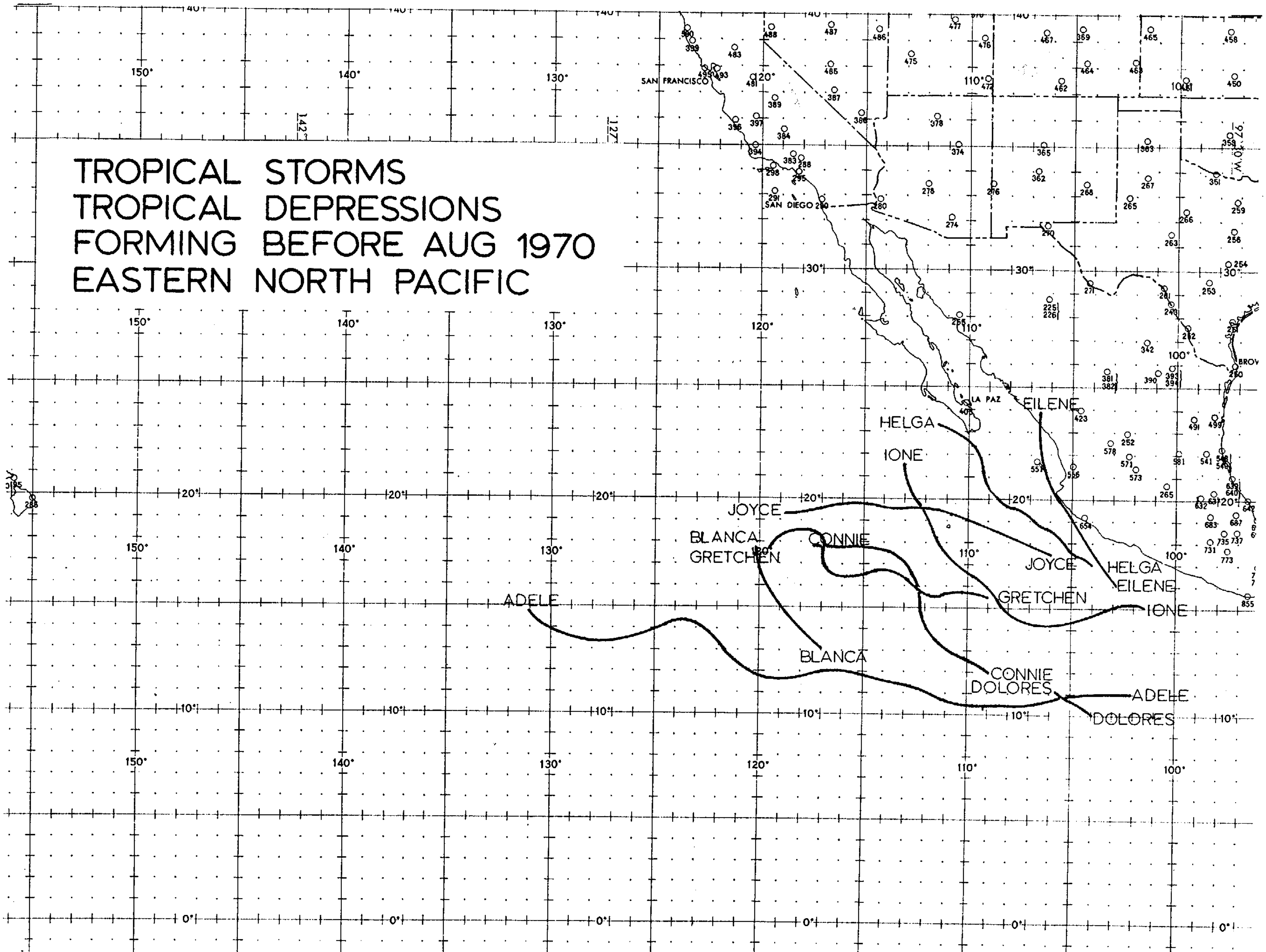
SUMMARY OF TROPICAL CYCLONES

IN THE

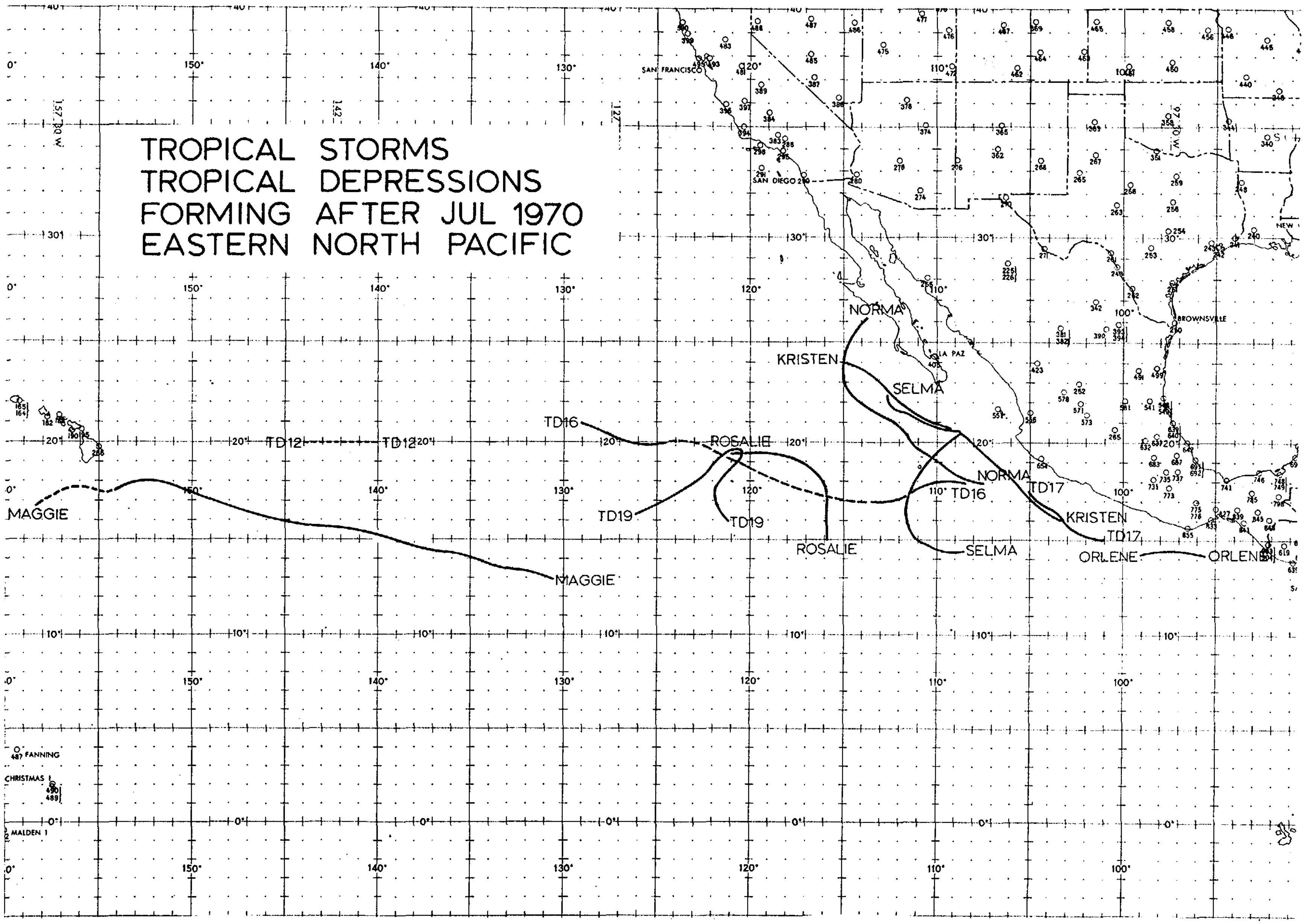
EASTERN NORTH PACIFIC OCEAN

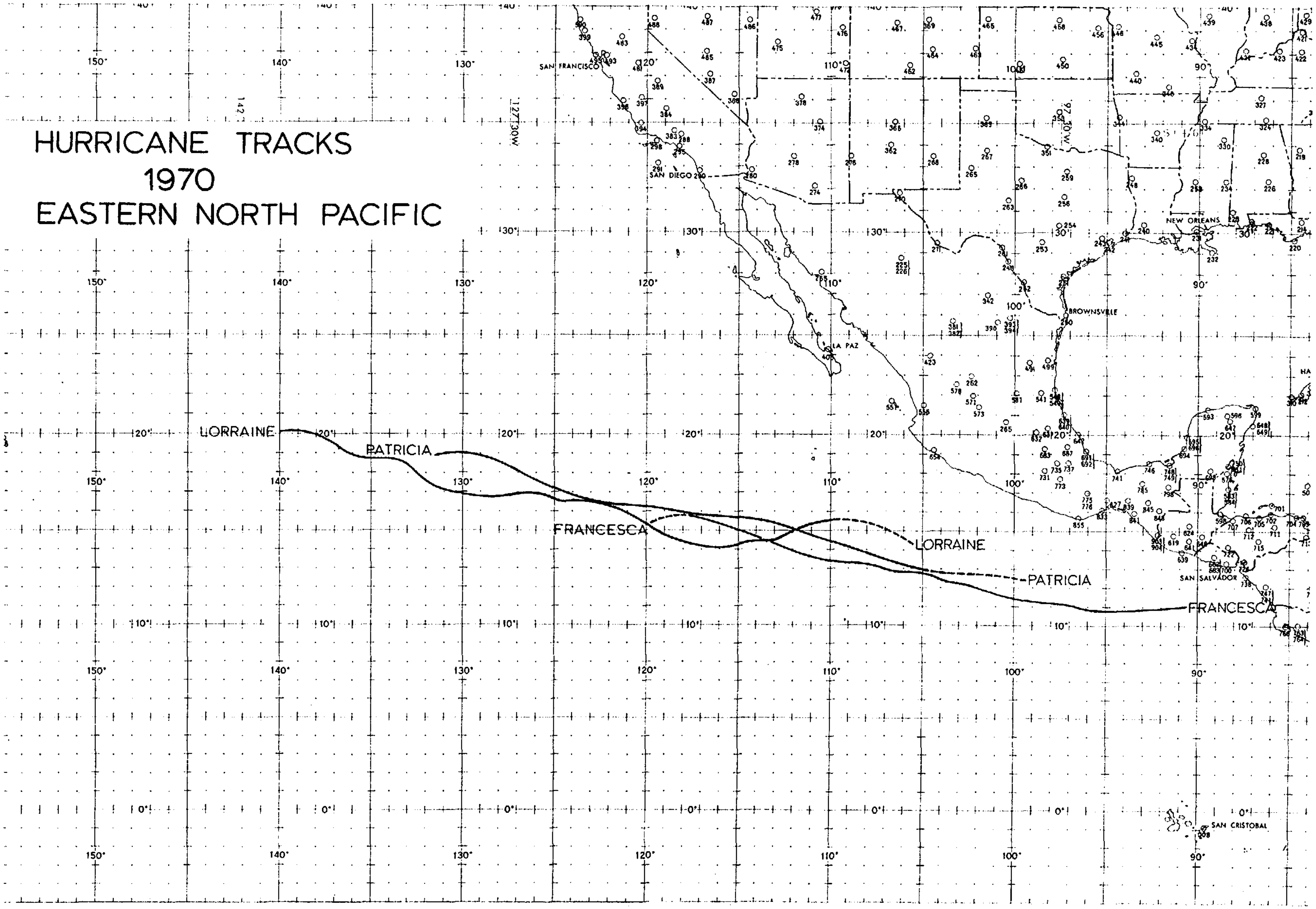
FOR

1970



TROPICAL STORMS
TROPICAL DEPRESSIONS
FORMING BEFORE AUG 1970
EASTERN NORTH PACIFIC


TROPICAL STORMS
TROPICAL DEPRESSIONS
FORMING AFTER JUL 1970
EASTERN NORTH PACIFIC
MAGGIE
TD12
TD16
TD17
TD19
ROSALIE
NORMA
KRISTEN
SELMA
ORLENE
SAN FRANCISCO
SAN DIEGO
LA PAZ
BROWNSVILLE
FANNING
CHRISTMAS I
MALDEN I


HURRICANE TRACKS
1970
EASTERN NORTH PACIFIC
LORRAINE
PATRICIA
FRANCESCA
LORRAINE
PATRICIA
FRANCESCA
SAN FRANCISCO
SAN DIEGO
NEW ORLEANS
BROWNSVILLE
LA PAZ
SAN SALVADOR
SAN CRISTOBAL

During the 1970 EASTPAC Tropical Cyclone season, Fleet Weather Central, Alameda issued a total of 350 tropical warnings on three hurricanes, fifteen tropical storms and three tropical depressions. Two tropical cyclones, "Hurricane LORRAINE" and Tropical Storm "MAGGIE" moved out of Alameda's area of responsibility. The total of twenty-one tropical cyclones represents the second highest year of record, with only 1968, when 25 cyclones were reported, exceeding this season. No specific reason for this increase over 1969 exists, however it is felt that increased knowledge and use of the weather satellite pictures, the use of reconnaissance aircraft throughout the season, and more active participation by Maritime observers transiting the Eastern Pacific region were of significant aid in more accurately describing the existing situation in EASTPAC.

The following five year summary covering tropical cyclones originating in Fleet Weather Central, Alameda's area of responsibility is presented for comparison. Included are warnings for prior years issued by Fleet Weather Central, Pearl Harbor, when the tropical cyclone originated in the Alameda area.

	1966	1967	1968	1969	1970
TOTAL NUMBER OF WARNINGS	342	474	531	219	350
CALENDAR DAYS OF WARNINGS	70	119	126	67	98
TROPICAL DEPRESSIONS	6	2	6	5	3
TROPICAL STORMS	6	12	13	6	15
HURRICANES	7	6	6	4	3
TOTAL TROPICAL CYCLONES	19	20	25	15	21

FORECASTING TOOLS: Tools used for forecasting tropical cyclone progress included twice daily readouts of the Fleet Numerical Weather Central, Monterey's "HATRACK" steering program; twice daily readouts of Fleet Weather Central, Pearl Harbor's "TYRACK" steering program, as well as extrapolation and subjective reasoning. Some of the greatest assets to forecasting included APT satellite pictures received daily via FOFAX and the satellite bulletins from FWF Suitland, Md.

Eastern Pacific hurricane flights by the EASTPAC detachment of VW-1, as well as recon fixes by the 55th Weather Recon Squadron, 9th Weather Wing, were invaluable for accurately tracking positions and determining intensities of tropical cyclones and hurricanes.

A total of 53 missions were flown in support of the 1970 Eastern Pacific Hurricane Center's recon requirements. Most recon flights were launched to provide daylight penetration and center fixes of the tropical cyclones, and at a time as close as possible to the daily weather satellite pass for a cross check on the accuracy of the satellite location of tropical cyclones from pictures. At least one mission was flown on every tropical cyclone that occurred.

Due to the restricted range of the Navy aircraft, fixes over 1200 miles from Point Mugu were made by the Air Force. Data obtained from the Air Force aircraft flying at both 300 and 500 mb levels were helpful in accurately determining positions and intensities of the tropical cyclones.

DAMAGE: Three tropical storms, "EILEEN", "HELGA", and "NORMA" went ashore, or passed close to the west coast of Mexico during 1970. One tropical storm, "MAGGIE", passed about 80 miles south of the island of Hawaii, dumping copious amounts of rain on the windward side of the "Big Island". Local flooding was reported as a result of "MAGGIE". No reports of damage from any of the three storms which struck Mexico are available, however, rainfall in excess of 5 inches was reported along the Mogollon Rim and in the Bradshaw Mountains of Arizona with local flooding and crop damage as a result of tropical storm "NORMA" going inland to the south in Baja, California. No dollar estimates of crop losses from cyclones in the Eastern Pacific are available.

TROPICAL CYCLONES FOR THE 1970 SEASON
ORIGINATED BY FLEET WEATHER CENTRAL, ALAMEDA

	CYCLONE	PERIOD
01	TROPICAL STORM ADELE	31 MAY - 07 JUN 1970
02	TROPICAL STORM BLANCA	09 JUN - 13 JUN 1970
03	TROPICAL STORM CONNIE	17 JUN - 22 JUN 1970
04	TROPICAL STORM DOLORES	19 JUN - 20 JUN 1970
05	TROPICAL STORM EILEEN	27 JUN - 29 JUN 1970
06	HURRICANE FRANCESCA	02 JUL - 09 JUL 1970
07	TROPICAL STORM GRETCHEN	14 JUL - 20 JUL 1970
08	TROPICAL STORM HELGA	16 JUL - 20 JUL 1970
09	TROPICAL STORM IONE	22 JUL - 26 JUL 1970
10	TROPICAL STORM JOYCE	29 JUL - 02 AUG 1970
11	TROPICAL STORM KRISTEN	05 AUG - 08 AUG 1970
12	HURRICANE LORRAINE	17 AUG - 26 AUG 1970
13	TROPICAL STORM MAGGIE	20 AUG - 22 AUG 1970
14	TROPICAL STORM NORMA	01 SEP - 05 SEP 1970
15	TROPICAL STORM ORLENE	07 SEP - 08 SEP 1970
16	TROPICAL DEPRESSION SIXTEEN	15 SEP - 21 SEP 1970
17	TROPICAL DEPRESSION SEVENTEEN	25 SEP - 26 SEP 1970
18	HURRICANE PATRICIA	04 OCT - 11 OCT 1970
19	TROPICAL DEPRESSION NINETEEN	20 OCT - 23 OCT 1970
20	TROPICAL STORM ROSALIE	21 OCT - 24 OCT 1970
21	TROPICAL STORM SELMA	01 NOV - 07 NOV 1970

TROPICAL DEPRESSIONS 1970
POSITION DATA

TROPICAL DEPRESSION ONE SIX
15 SEP - 21 SEP

DTG	LAT	LONG	DTG	LAT	LONG
151800Z	18.0N	108.3W	*201800Z	20.0N	124.5W
160000Z	18.0N	110.0W	210000Z	19.9N	125.2W
160600Z	17.7N	110.9W	210600Z	20.1N	126.5W
161200Z	17.3N	111.7W	211200Z	20.5N	127.8W
161800Z	17.0N	112.6W	211800Z	21.0N	129.0W

TROPICAL DEPRESSION ONE SEVEN
25 SEP - 26 SEP

DTG	LAT	LONG	DTG	LAT	LONG
251800Z	15.2N	101.0W	261200Z	17.0N	104.4W
260000Z	15.7N	102.7W	261800Z	17.5N	105.0W
260600Z	16.5N	103.6W			

TROPICAL DEPRESSION ONE NINE
20 OCT - 23 OCT

DTG	LAT	LONG	DTG	LAT	LONG
201800Z	16.0N	121.1W	221200Z	18.4N	122.6W
210000Z	16.8N	121.7W	221800Z	17.8N	123.3W
210600Z	17.9N	121.7W	230000Z	17.4N	124.0W
211200Z	18.6N	121.2W	230600Z	17.0N	124.7W
211800Z	19.5N	120.5W	231200Z	16.7N	125.3W
220000Z	19.4N	121.3W	231800Z	16.4N	126.1W
220600Z	18.9N	122.0W			

*REGENERATED

TROPICAL STORMS 1970
POSITION DATA

TROPICAL STORM ADELE
31 MAY - 07 JUN

DTG	LAT	LONG	DTG	LAT	LONG
310600Z	11.0N	102.1W	031800Z	11.7N	118.7W
311200Z	11.0N	102.9W	040000Z	11.8N	119.8W
311800Z	11.0N	103.7W	040600Z	12.2N	120.8W
010000Z	10.9N	104.4W	041200Z	12.8N	121.6W
010600Z	10.8N	105.5W	041800Z	13.7N	122.2W
011200Z	10.6N	106.5W	050000Z	14.2N	123.1W
011800Z	10.5N	107.6W	050600Z	14.3N	124.1W
020000Z	10.5N	108.7W	051200Z	14.0N	125.0W
020600Z	10.5N	110.0W	051800Z	13.7N	125.8W
021200Z	10.8N	111.3W	060000Z	13.5N	126.9W
021800Z	11.2N	112.6W	060600Z	13.5N	128.1W
030000Z	11.6N	113.9W	061200Z	13.7N	129.2W
030600Z	11.9N	115.4W	061800Z	14.1N	130.3W
031200Z	12.0N	117.0W	070000Z	14.8N	131.1W

TROPICAL STORM BLANCA
09 JUN - 13 JUN

DTG	LAT	LONG	DTG	LAT	LONG
091800Z	13.1N	117.0W	111800Z	14.9N	119.0W
100000Z	13.5N	117.5W	120000Z	15.1N	119.1W
100600Z	13.8N	117.9W	120600Z	15.3N	119.2W
101200Z	13.9N	118.0W	121200Z	15.8N	119.6W
101800Z	14.1N	118.2W	121800Z	16.3N	119.8W
110000Z	14.3N	118.4W	130000Z	16.9N	120.0W
110600Z	14.5N	118.6W	130600Z	17.4N	120.0W
111200Z	14.7N	118.7W	131200Z	17.8N	120.1W

TROPICAL STORM CONNIE
17 JUN - 22 JUN

DTG	LAT	LONG	DTG	LAT	LONG
171800Z	12.0N	109.0W	201200Z	17.0N	113.0W
180000Z	12.4N	109.7W	201800Z	17.3N	113.4W
180600Z	12.7N	110.4W	210000Z	17.5N	113.8W
181200Z	13.2N	111.1W	210600Z	17.7N	114.3W
181800Z	13.7N	111.7W	211200Z	17.8N	114.8W
190000Z	14.2N	112.0W	211800Z	17.8N	115.3W
190600Z	14.7N	112.2W	220000Z	17.8N	115.8W
191200Z	15.2N	112.2W	220600Z	17.8N	116.3W
191800Z	15.7N	112.3W	221200Z	17.8N	116.8W
200000Z	16.2N	112.4W	221800Z	17.9N	117.3W
200600Z	16.6N	112.7W			

TROPICAL STORM DOLORES
19 JUN - 20 JUN

DTG	LAT	LONG	DTG	LAT	LONG
191800Z	10.0N	104.0W	201200Z	10.8N	105.3W
200000Z	10.3N	104.4W	210000Z	11.1N	105.7W
200600Z	10.5N	104.8W			

TROPICAL STORM EILEEN
27 JUN - 29 JUN

DTG	LAT	LONG	DTG	LAT	LONG
271800Z	16.0N	102.9W	281800Z	20.2N	105.8W
280000Z	17.1N	103.7W	290000Z	21.3N	106.3W
280600Z	18.1N	104.4W	290600Z	22.5N	106.6W
281200Z	19.2N	105.1W	291200Z	23.8N	106.6W

TROPICAL STORM GRETCHEN
14 JUL - 20 JUL

DTG	LAT	LONG	DTG	LAT	LONG
141800Z	15.5N	109.0W	180000Z	17.8N	116.8W
150000Z	15.8N	110.3W	180600Z	17.9N	116.8W
150600Z	15.6N	111.6W	181200Z	17.9N	116.9W
151200Z	16.2N	112.7W	181800Z	18.0N	116.9W
151800Z	16.7N	113.8W	190000Z	18.2N	117.1W
160000Z	16.7N	114.3W	190600Z	18.3N	117.3W
160600Z	16.6N	114.8W	191200Z	18.4N	117.5W
161200Z	16.5N	115.3W	191800Z	18.5N	117.8W
161800Z	16.5N	115.8W	200000Z	18.5N	118.3W
170000Z	16.6N	116.3W	200600Z	18.3N	118.9W
170600Z	16.8N	116.7W	201200Z	18.0N	119.2W
171200Z	17.2N	117.0W	201800Z	17.7N	119.5W
171800Z	17.7N	116.8W			

TROPICAL STORM HELGA
16 JUL - 20 JUL

DTG	LAT	LONG	DTG	LAT	LONG
161800Z	17.0N	104.0W	181800Z	19.8N	108.2W
170000Z	17.3N	104.5W	190000Z	20.3N	108.7W
170600Z	17.6N	105.0W	190600Z	20.9N	109.1W
171200Z	18.0N	105.4W	191200Z	21.6N	109.3W
171800Z	18.3N	105.7W	191800Z	22.2N	109.7W
180000Z	18.7N	106.3W	200000Z	22.7N	110.2W
180600Z	19.1N	106.9W	200600Z	23.0N	110.8W
181200Z	19.5N	107.5W	201200Z	23.3N	111.5W

TROPICAL STORM IONE
22 JUL - 26 JUL

DTG	LAT	LONG	DTG	LAT	LONG
221800Z	15.0N	101.5W	250600Z	17.8N	111.2W
230000Z	15.2N	102.5W	251200Z	18.7N	111.7W
**240000Z	15.5N	108.6W	251800Z	19.7N	112.1W
240600Z	15.9N	109.1W	260000Z	20.0N	112.5W
241200Z	16.3N	109.6W	260600Z	20.5N	112.8W
241800Z	16.7N	110.1W	261200Z	21.0N	113.0W
250000Z	17.0N	110.5W	261800Z	21.5N	113.0W

TROPICAL STORM JOYCE
29 JUL - 02 AUG

DTG	LAT	LONG	DTG	LAT	LONG
291800Z	17.5N	106.0W	010000Z	19.6N	112.9W
300000Z	17.8N	106.8W	010600Z	19.7N	113.8W
300600Z	18.1N	107.5W	011200Z	19.8N	114.6W
301200Z	18.4N	108.2W	011800Z	19.8N	115.5W
301800Z	18.7N	108.9W	020000Z	19.7N	116.3W
310000Z	19.0N	109.7W	020600Z	19.6N	117.1W
310600Z	19.3N	110.5W	021200Z	19.5N	117.9W
311200Z	19.5N	111.3W	021800Z	19.3N	118.8W
311800Z	19.6N	112.2W			

TROPICAL STORM KRISTEN
05 AUG - 08 AUG

DTG	LAT	LONG	DTG	LAT	LONG
051800Z	16.0N	103.0W	071200Z	21.0N	110.0W
060000Z	16.4N	103.9W	071800Z	21.9N	111.8W
060600Z	17.0N	104.7W	080000Z	22.6N	112.4W
061200Z	17.7N	105.4W	080600Z	23.2N	113.1W
061800Z	18.4N	106.1W	081200Z	23.7N	113.9W
070000Z	19.5N	107.2W	081800Z	24.0N	115.0W
070600Z	20.5N	108.5W			

TROPICAL STORM MAGGIE
20 AUG - 22 AUG

DTG	LAT	LONG	DTG	LAT	LONG
201800Z	13.0N	130.5W	220000Z	14.2N	135.4W
210000Z	13.3N	131.5W	220600Z	14.4N	136.5W
210600Z	13.5N	132.5W	221200Z	14.6N	137.5W
211200Z	13.6N	133.5W	*221800Z	14.8N	138.6W
211800Z	13.9N	134.4W			

*PASSED TO FWC HAWAII
**REGENERATED

TROPICAL STORM NORMA
01 SEP - 05 SEP

DTG	LAT	LONG	DTG	LAT	LONG
010000Z	18.0N	107.5W	031200Z	21.9N	113.9W
010600Z	18.1N	108.1W	031800Z	22.4N	114.5W
011200Z	18.3N	108.6W	040000Z	22.6N	114.7W
011800Z	18.6N	109.2W	040600Z	22.9N	114.9W
020000Z	19.0N	109.8W	041200Z	23.1N	114.9W
020600Z	19.4N	110.5W	041800Z	23.4N	114.9W
021200Z	19.9N	111.2W	050000Z	23.8N	115.0W
021800Z	20.5N	111.6W	050600Z	24.4N	115.0W
030000Z	21.1N	112.3W	051200Z	25.0N	114.7W
030600Z	21.4N	113.1W	051800Z	26.2N	113.8W

TROPICAL STORM ORLENE
07 SEP - 08 SEP

DTG	LAT	LONG	DTG	LAT	LONG
072100Z	14.3N	95.5W	081200Z	14.6N	98.0W
080000Z	14.4N	96.0W	081800Z	14.3N	99.0W
080600Z	14.6N	97.0W			

TROPICAL STORM ROSALIE
21 OCT - 24 OCT

DTG	LAT	LONG	DTG	LAT	LONG
211800Z	15.0N	115.9W	230600Z	19.4N	118.2W
220000Z	15.9N	115.9W	231200Z	19.5N	119.1W
220600Z	16.8N	115.9W	231800Z	19.5N	120.0W
221200Z	17.7N	116.1W	240000Z	19.5N	120.5W
221800Z	18.6N	116.6W	240600Z	19.5N	121.0W
230000Z	19.1N	117.3W			

TROPICAL STORM SELMA
01 NOV - 07 NOV

DTG	LAT	LONG	DTG	LAT	LONG
011800Z	14.5N	108.5W	041200Z	19.8N	109.7W
020000Z	14.5N	109.2W	041800Z	20.2N	109.2W
020600Z	14.6N	109.8W	050000Z	20.5N	108.8W
021200Z	14.8N	110.4W	050600Z	20.7N	109.4W
021800Z	15.0N	111.0W	051200Z	20.8N	110.0W
030000Z	15.8N	111.5W	051800Z	21.0N	110.6W
030600Z	16.7N	111.6W	060000Z	21.2N	111.1W
031200Z	17.5N	111.4W	060600Z	21.4N	111.6W
031800Z	18.3N	111.0W	061200Z	21.6N	112.0W
040000Z	18.8N	110.6W	061800Z	21.9N	112.4W
040600Z	19.3N	110.2W	070000Z	22.3N	112.7W

INDIVIDUAL HURRICANE TRACKS

FOR 1970

IN THE EASTERN NORTH PACIFIC OCEAN

HURRICANE FRANCESCA
021600Z JUL TO 090000Z JUL 1970

I. DATA

A. STATISTICS

1. NUMBER OF WARNINGS ISSUED - 27
2. NUMBER OF WARNINGS WITH HURRICANE INTENSITY - 9
3. TOTAL DISTANCE TRAVELED DURING TROPICAL WARNING PERIOD - 1780NM.

B. CHARACTERISTICS

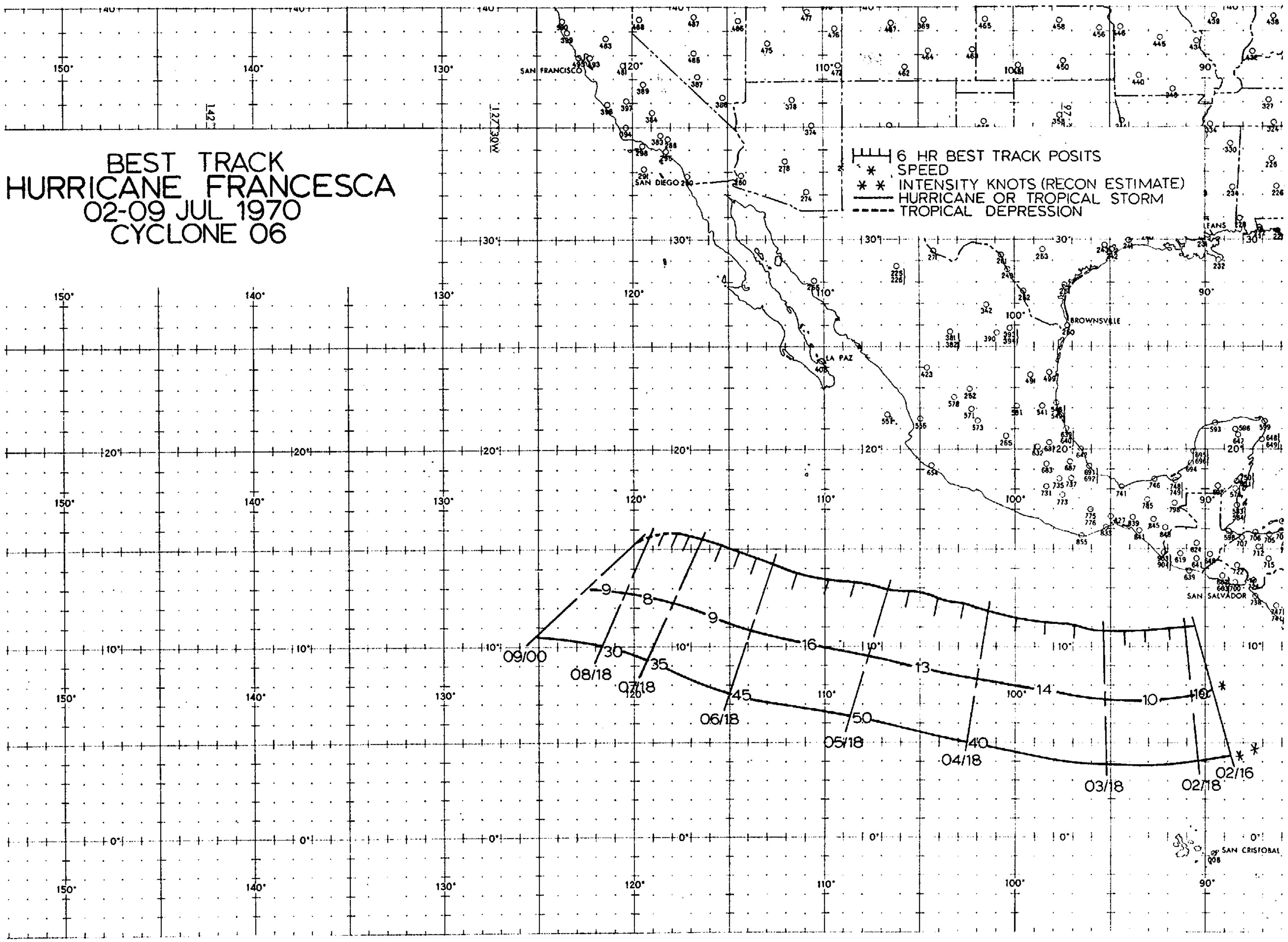
1. MINIMUM OBSERVED SLP - 991.0MB
2. MINIMUM OBSERVED 700MB HEIGHT - NOT OBSERVED
3. MAXIMUM SURFACE WIND - 80 KTS (EST.)
4. MAXIMUM RADIUS OF SURFACE CIRCULATION - 360 MI.

II. DEVELOPMENT

A. INITIAL IMPETUS - ITCZ (TROPICAL CYCLONE #6)
B. INITIAL SURFACE VORTEX: 021600Z (ESSA 8)
C. TIME STORM REACHED HURRICANE INTENSITY: 031800Z

III. FINAL DISPOSITION

A. DISSIPATED OVER WATER


BEST TRACK
HURRICANE FRANCESCA
02-09 JUL 1970
CYCLONE 06
6 HR BEST TRACK POSITS
* SPEED
* * INTENSITY KNOTS (RECON ESTIMATE)
HURRICANE OR TROPICAL STORM
TROPICAL DEPRESSION
SAN FRANCISCO
SAN DIEGO
BROWNSVILLE
LA PAZ
SAN SALVADOR
SAN CRISTOBAL
09/00
08/18
07/18
06/18
05/18
04/18
03/18
02/18
02/16
30
35
45
50
40
9
8
9
16
13
14
10
10

POSITION FROM BEST TRACK AND VERIFICATION DATA

	STORM POSIT		24 HR ERROR	48 HR ERROR	72 HR ERROR
TIME	LAT	LONG	DEG/DIST	DEG/DIST	DEG/DIST
021600Z	11.0N	90.6W	-	-	-
021800Z	11.0N	91.0W	-	-	-
030000Z	10.9N	91.9W	-	-	-
030600Z	10.9N	93.1W	-	-	-
031200Z	10.8N	94.2W	-	-	-
031800Z	10.8N	95.3W	035/100	-	-
040000Z	11.0N	96.9W	050/135	-	-
040600Z	11.2N	98.4W	060/156	-	-
041200Z	11.4N	99.9W	055/102	-	-
041800Z	11.8N	101.3W	090/125	-	-
050000Z	12.2N	102.7W	120/174	070/270	-
050600Z	12.6N	104.0W	115/246	075/275	-
051200Z	12.9N	105.4W	100/246	075/246	-
051800Z	13.0N	106.7W	340/048	085/268	-
060000Z	13.3N	108.3W	125/063	115/220	075/405
060600Z	13.5N	109.8W	115/080	110/359	-
061200Z	13.8N	111.3W	265/055	095/366	080/435
061800Z	14.3N	112.7W	080/090	050/097	-
070000Z	14.6N	113.6W	330/047	130/105	115/266
070600Z	14.9N	114.4W	310/085	145/096	-
071200Z	15.2N	115.3W	340/031	250/172	090/379
071800Z	15.5N	116.3W	295/108	040/054	-
080000Z	15.7N	117.0W	285/140	305/189	198/098
080600Z	15.9N	117.7W	290/182	300/237	-
081200Z	15.9N	118.4W	290/216	315/128	260/336
081800Z	15.8N	119.1W	-	315/235	-
090000Z	15.6N	119.8W	-	-	-

24 HOUR FORECAST ERROR = 121 MI
48 HOUR FORECAST ERROR = 207 MI
72 HOUR FORECAST ERROR = 320 MI

EYE FIXES TROPICAL CYCLONE #6 (HURRICANE FRANCESCA)

FIX NO.	TIME	POSIT	UNIT/ACCURACY		FLT LVL	OBS. SFC WND	OBS. SLP	MIN 700 HT	FLT LVL TT/TO	EYE FORM	ORIEN TATION	DIAM EYE
1	041800Z	11.6N 101.3W	9th AF	20nm	500/300mb	40KTS	991.0	-	- -	E	01/20	15
2	051815Z	13.0N 106.7W	9th AF	20nm	500/300mb	50KTS	988.0	-	- -	C		30
3	061740Z	14.2N 112.6W	9th AF	10nm	500/300mb	45KTS	-	-	- -	C		35
4	071735Z	15.4N 116.3W	VW-1	15nm	700mb	35KTS	-	-	- -	C		15
5	081737Z	15.7N 119.1W	VW-1	20nm	700mb	30KTS	1006.0	-	- -	C		10

HURRICANE LORRAINE
172200Z AUG TO 261800Z AUG 1970

I. DATA

A. STATISTICS

1. NUMBER OF WARNINGS ISSUED - 37
2. NUMBER OF WARNINGS WITH HURRICANE INTENSITY - 11
3. TOTAL DISTANCE TRAVELED DURING TROPICAL WARNING PERIOD - 2070NM.

B. CHARACTERISTICS

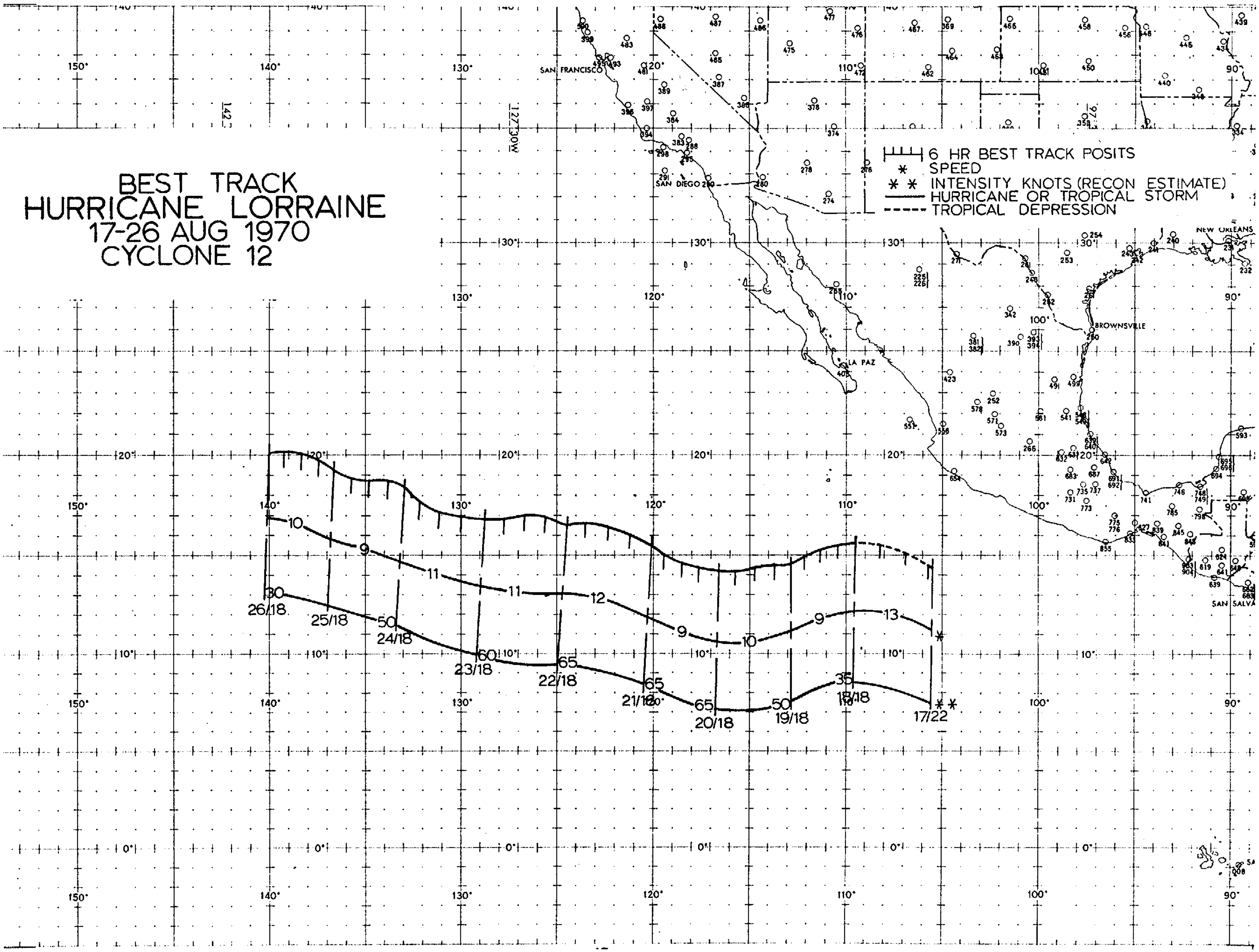
1. MINIMUM OBSERVED SLP - 963MB
2. MINIMUM OBSERVED 700MB HEIGHT - NOT OBSERVED
3. MAXIMUM SURFACE WIND - 85 KTS
4. MAXIMUM RADIUS OF SURFACE CIRCULATION - 330 MI.

II. DEVELOPMENT

A. INITIAL IMPETUS - ITCZ (TROPICAL CYCLONE #12)
B. INITIAL SURFACE VORTEX: 172200Z (ITOS - 1)
C. TIME STORM REACHED HURRICANE INTENSITY - 201800Z

III. FINAL DISPOSITION

A. DISSIPATED OVER WATER (PASSED TO HAWAII)


BEST TRACK
HURRICANE LORRAINE
17-26 AUG 1970
CYCLONE 12
6 HR BEST TRACK POSITS
* SPEED
* * INTENSITY KNOTS (RECON ESTIMATE)
HURRICANE OR TROPICAL STORM
TROPICAL DEPRESSION
SAN FRANCISCO
SAN DIEGO
LA PAZ
BROWNSVILLE
NEW ORLEANS
26/18
25/18
24/18
23/18
22/18
21/18
20/18
19/18
18/18
17/22

AN-19

POSITION FROM BEST TRACK AND VERIFICATION DATA

	STORM POSIT		24 HR ERROR	48 HR ERROR	72 HR ERROR
TIME	LAT	LONG	DEG/DIST	DEG/DIST	DEG/DIST
172200Z	14.3N	105.5W	-	-	-
180000Z	14.4N	105.7W	-	-	-
180600Z	15.0N	106.9W	-	-	-
181200Z	15.4N	108.2W	-	-	-
181800Z	15.5N	109.5W	-	-	-
190000Z	15.4N	110.4W	045/074	-	-
190600Z	15.2N	111.3W	040/123	-	-
191200Z	14.9N	112.1W	025/164	-	-
191800Z	14.5N	112.8W	345/147	-	-
200000Z	14.4N	113.7W	350/172	-	-
200600Z	14.3N	114.7W	350/200	-	-
201200Z	14.2N	115.7W	355/225	-	-
201800Z	14.2N	116.6W	060/039	350/250	-
210000Z	14.3N	117.6W	160/068	350/258	-
210600Z	14.6N	118.5W	180/078	350/260	-
211200Z	15.0N	119.4W	200/032	350/260	-
211800Z	15.4N	120.1W	185/070	135/075	-
220000Z	15.9N	121.2W	165/105	180/162	350/252
220600Z	16.3N	122.3W	160/132	180/180	-
221200Z	16.6N	123.5W	155/156	140/076	-
221800Z	16.4N	124.5W	100/087	135/123	-
230000Z	16.9N	125.6W	095/101	150/188	175/222
230600Z	16.9N	126.7W	085/120	145/198	-
231200Z	16.8N	127.8W	070/150	140/200	090/131
231800Z	16.8N	128.8W	010/084	075/155	-
240000Z	16.9N	130.0W	010/103	075/198	135/224
240600Z	17.1N	131.1W	010/109	075/218	-
241200Z	17.6N	132.1W	010/066	080/232	135/282
241800Z	18.3N	132.9W	185/110	005/078	-
250000Z	18.6N	133.8W	200/102	355/087	090/246
250600Z	18.6N	134.8W	205/101	350/096	-
251200Z	18.8N	135.7W	200/114	260/042	080/273
251800Z	19.2N	136.6W	260/035	190/213	-
260000Z	19.7N	137.4W	240/054	218/184	340/108
260600Z	20.0N	138.3W	245/060	205/204	-
261200Z	20.1N	139.2W	060/152	205/210	220/124
261800Z	20.0N	140.0W	095/073	270/090	-

PASSED TO FLEET WEATHER CENTRAL, PEARL HARBOR

24 HR FORECAST ERROR = 106 MI
48 HR FORECAST ERROR = 169 MI
72 HR FORECAST ERROR = 203.9 MI

EYE FIXES TROPICAL CYCLONE #12 (HURRICANE LORRAINE)

FIX NO.	TIME	POSIT		UNIT/ACCURACY		FLT LVL	OBS. SFC WND	OBS. SLP	MIN 700 HT	FLT LVL TT/TO	EYE FORM	ORIENTATION	DIAM EYE
1	181806Z	15.4N	109.6W	9th AF	10nm	500mb	35KTS	-	3136M	- -	C		10
2	191845Z	14.5N	112.8W	VW-1	10nm	700mb	50KTS	-	-	26/22	E	09/20	10
3	201830Z	14.2N	116.6W	9th AF	10nm	500mb	65KTS	988(c)	2969M	- -	E	10/30	20
4	211720Z	15.4N	120.1W	9th AF	10nm	300mb	65KTS	978	2838M	- -	C		20
5	221730Z	16.7N	124.4W	9th AF	15nm	300mb	65KTS	963	-	- -	C		17
6	231750Z	16.8N	128.7W	9th AF	25nm	300mb	60KTS	986	-	25/31	C		20
7	241830Z	18.3N	133.1W	9th AF	10nm	300mb	50KTS	994	-	29/33	C		20
8	261830Z	20.0N	140.0W	9th AF	10nm	300mb	30KTS	-	-	- -	C		40

HURRICANE PATRICIA
042100Z OCT TO 111800Z OCT 1970

I. DATA

A. STATISTICS

1. NUMBER OF WARNINGS ISSUED - 29
2. NUMBER OF WARNINGS WITH HURRICANE INTENSITY - 13
3. TOTAL DISTANCE TRAVELED DURING TROPICAL WARNING PERIOD - 1860NM.

B. CHARACTERISTICS

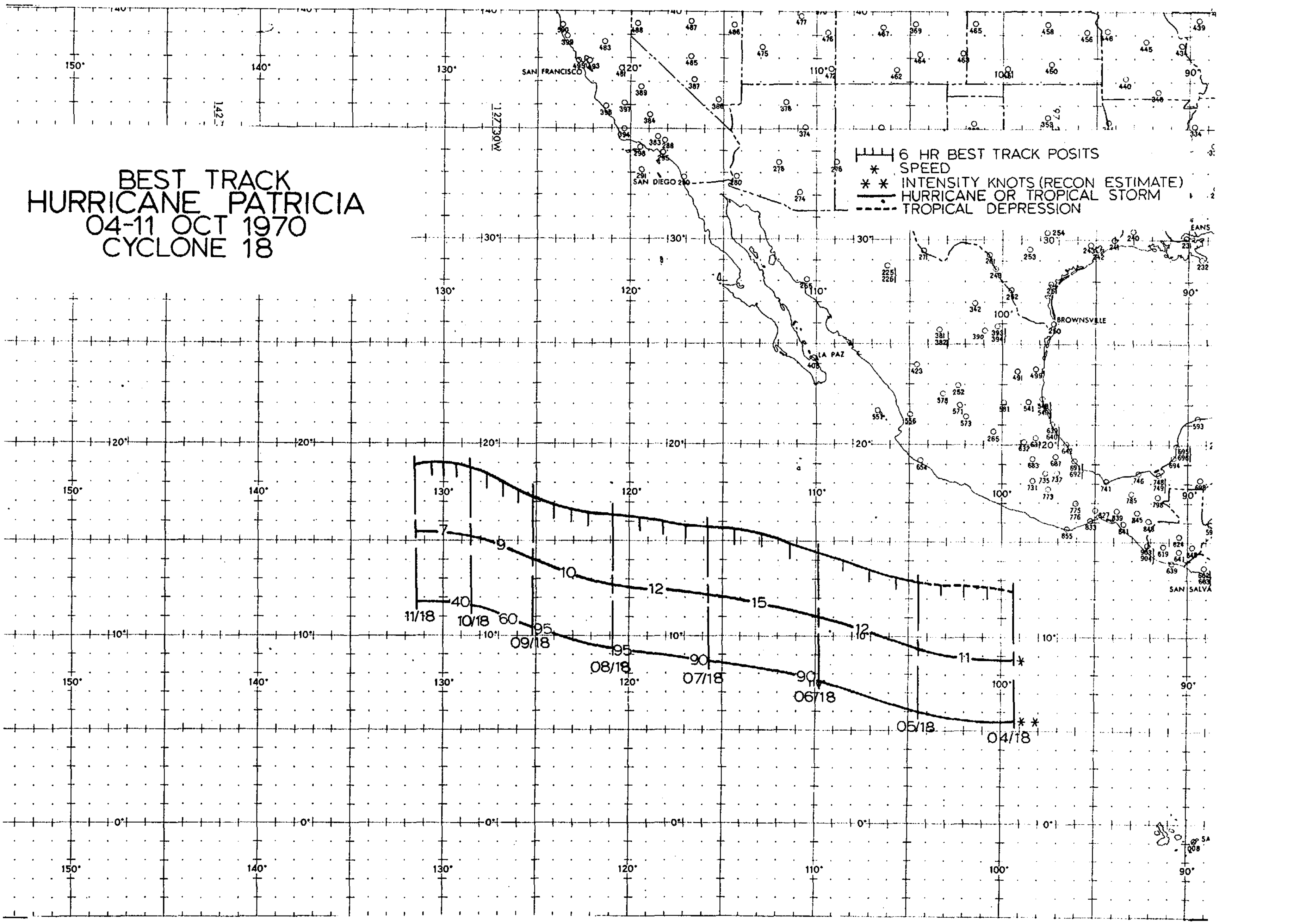
1. MINIMUM OBSERVED SLP - 976 MB
2. MINIMUM OBSERVED 700 MB HEIGHT - NOT OBSERVED
3. MAXIMUM SURFACE WIND - 95 KTS
4. MAXIMUM RADIUS OF SURFACE CIRCULATION - 360 MI.

II. DEVELOPMENT

A. INITIAL IMPETUS - ITCZ (TROPICAL CYCLONE #18)
B. INITIAL SURFACE VORTEX: 042100Z (ITOS - 1)
C. TIME STORM REACHED HURRICANE INTENSITY - 061800Z

III. FINAL DISPOSITION

A. DISSIPATED OVER WATER


BEST TRACK
HURRICANE PATRICIA
04-11 OCT 1970
CYCLONE 18
6 HR BEST TRACK POSITS
* SPEED
* * INTENSITY KNOTS (RECON ESTIMATE)
HURRICANE OR TROPICAL STORM
TROPICAL DEPRESSION
SAN FRANCISCO
SAN DIEGO
LA PAZ
BROWNSVILLE
SAN SALVA
11/18
10/18
09/18
08/18
07/18
06/18
05/18
04/18
7
9
10
12
15
12
11
40
60
95
95
90
90

POSITION FROM BEST TRACK AND VERIFICATION DATA

	STORM POSIT		24 HR ERROR	48 HR ERROR	72 HR ERROR
TIME	LAT	LONG	DEG/DIST	DEG/DIST	DEG/DIST
041800Z	12.4N	99.6W	-	-	-
050000Z	12.6N	100.8W	-	-	-
050600Z	12.7N	102.0W	-	-	-
051200Z	12.8N	103.2W	-	-	-
051800Z	12.9N	104.4W	085/173	-	-
060000Z	13.1N	105.6W	160/100	-	-
060600Z	13.5N	107.0W	155/132	-	-
061200Z	14.0N	108.4W	125/144	-	-
061800Z	14.5N	109.8W	130/072	-	-
070000Z	14.9N	111.3W	135/096	-	-
070600Z	15.4N	112.8W	130/145	-	-
071200Z	15.7N	114.3W	120/177	-	-
071800Z	15.8N	115.7W	050/037	125/143	-
080000Z	15.9N	116.9W	020/069	105/181	-
080600Z	16.1N	118.1W	020/090	100/190	-
081200Z	16.3N	119.4W	055/188	095/205	-
081800Z	16.5N	120.8W	290/036	110/039	-
090000Z	16.6N	122.2W	300/028	060/048	080/252
090600Z	16.8N	123.0W	090/066	050/357	-
091200Z	17.0N	124.0W	270/107	055/378	075/247
091800Z	17.4N	125.1W	295/039	230/067	-
100000Z	17.7N	125.9W	270/066	230/105	220/055
100600Z	18.1N	126.8W	290/050	225/146	-
101200Z	18.4N	127.6W	310/075	240/216	050/495
101800Z	18.7N	128.5W	270/084	350/104	-
110000Z	18.9N	129.2W	015/348	330/097	220/235
110600Z	18.9N	129.9W	045/450	295/147	-
111200Z	18.9N	130.6W	020/455	330/180	245/345
111800Z	18.9N	131.4W	290/084	330/177	-

24 HR FORECAST ERROR = 132 MI
48 HR FORECAST ERROR = 163.5 MI
72 HR FORECAST ERROR = 271.5 MI

EYE FIXES TROPICAL CYCLONE #18 (HURRICANE PATRICIA)

FIX NO.	TIME	POSIT		UNIT/ACCURACY		FLT LVL	OBS. SFC WND	OBS. SLP	MIN 700 HT	FLT LVL TT/TO	EYE FORM	ORIEN- TATION	DIAM EYE
1	061829Z	14.5N	109.9W	9th AF	10nm	500mb	90KTS	979	-	15/10	C		15 *
2	071825Z	15.8N	115.7W	VW-1	10nm	700mb	90KTS	976	2801M	22/14	C		15 *
3	081750Z	16.5N	120.8W	9th AF	10nm	500mb	95KTS	-	-	- -	C		15
4	091745Z	17.4N	125.1W	VW-1	20nm	700mb	95KTS	980	-	25/23	C		15 *
5	100000Z	18.7N	125.7W	9th AF(FAN)	20nm	300mb	60KTS	-	-	- -	C		15
6	101830Z	18.7N	128.5W	VW-1	15nm	700mb	40KTS	-	-	23/22	C		20

* CLOSED WALL CLOUD AT 061829Z   WALL CLOUD 12 MILES THICK AT 071825Z

WALL CLOUD 10 MILES THICK AT 091745Z

Fleet Weather Central, Pearl Harbor issued warnings on three tropical cyclones in 1970. Only one of these systems, Hurricane Dot, originated in the Central Pacific. Tropical Storm Maggie developed in the Fleet Weather Central, Alameda area of responsibility. Tropical Depression One Two, previously Hurricane Lorraine in the Eastern Pacific, existed only as a tropical depression in the Central Pacific.

Total Number of Warnings	27
Calendar Days of Warnings	8
Tropical Depressions	1
Tropical Storms	1
Hurricanes	1
Total Tropical Cyclones	3

No damage resulting from tropical cyclone activity was reported during 1970. In its formative stages Hurricane Dot passed near Midway Island causing increased precipitation and winds. Tropical Storm Maggie passed south of the Island of Hawaii where above normal cloudiness and precipitation were reported. Post analysis of data indicated that Hurricane Dot was possibly a regeneration of Tropical Storm Maggie. The distance between the position in the final warning on Maggie and the first warning on Dot was 1550 miles. The elapsed time indicates an average speed of 9 knots during this period. The connection was supported mainly by satellite pictures.

All warnings were coordinated with the Central Pacific Hurricane Center, Honolulu in accordance with the National Hurricane Operations Plan. The main forecasting tool used by Fleet Weather Central, Pearl Harbor was TYRACK, a computerized forecasting system based on tropical wind fields.

TROPICAL CYCLONES FOR THE 1970 SEASON

CYCLONE	PERIOD
TROPICAL STORM MAGGIE	23 AUG - 27 AUG 1970
TROPICAL DEPRESSION ONE TWO	26 AUG - 27 AUG 1970
HURRICANE DOT	2 SEP - 4 SEP 1970

TROPICAL STORMS 1970
POSITION DATA

TROPICAL STORM MAGGIE
23 AUG - 27 AUG

DTG	LAT	LONG	DTG	LAT	LONG
230000Z	14.8N	139.0W	250600Z	17.7N	151.4W
230600Z	15.0N	139.9W	251200Z	18.1N	152.9W
231200Z	15.1N	140.7W	251800Z	17.3N	154.0W
231800Z	15.3N	142.0W	260000Z	17.5N	155.5W
240000Z	15.5N	143.0W	260600Z	17.5N	156.6W
240600Z	15.8N	144.7W	261200Z	17.5N	157.7W
241200Z	15.9N	145.8W	261800Z	17.2N	157.0W
241800Z	17.0N	149.0W	270000Z	17.2N	157.8W
250000Z	17.4N	150.1W			

TROPICAL DEPRESSIONS 1970
POSITION DATA

TROPICAL DEPRESSION ONE TWO
26 AUG - 27 AUG

DTG	LAT	LONG	DTG	LAT	LONG
270000Z	20.0N	141.0W	271200Z	20.0N	143.0W
270600Z	20.0N	142.0W	271800Z	20.0N	144.0W

HURRICANE DOT

021800Z SEP TO 040600Z SEPTEMBER 1970

I. DATA

A. STATISTICS

1. NUMBER OF WARNINGS ISSUED - 8
2. NUMBER OF WARNINGS WITH HURRICANE INTENSITY - 2
3. TOTAL DISTANCE TRAVELED DURING WARNING PERIOD - 665 MI.

B. CHARACTERISTICS

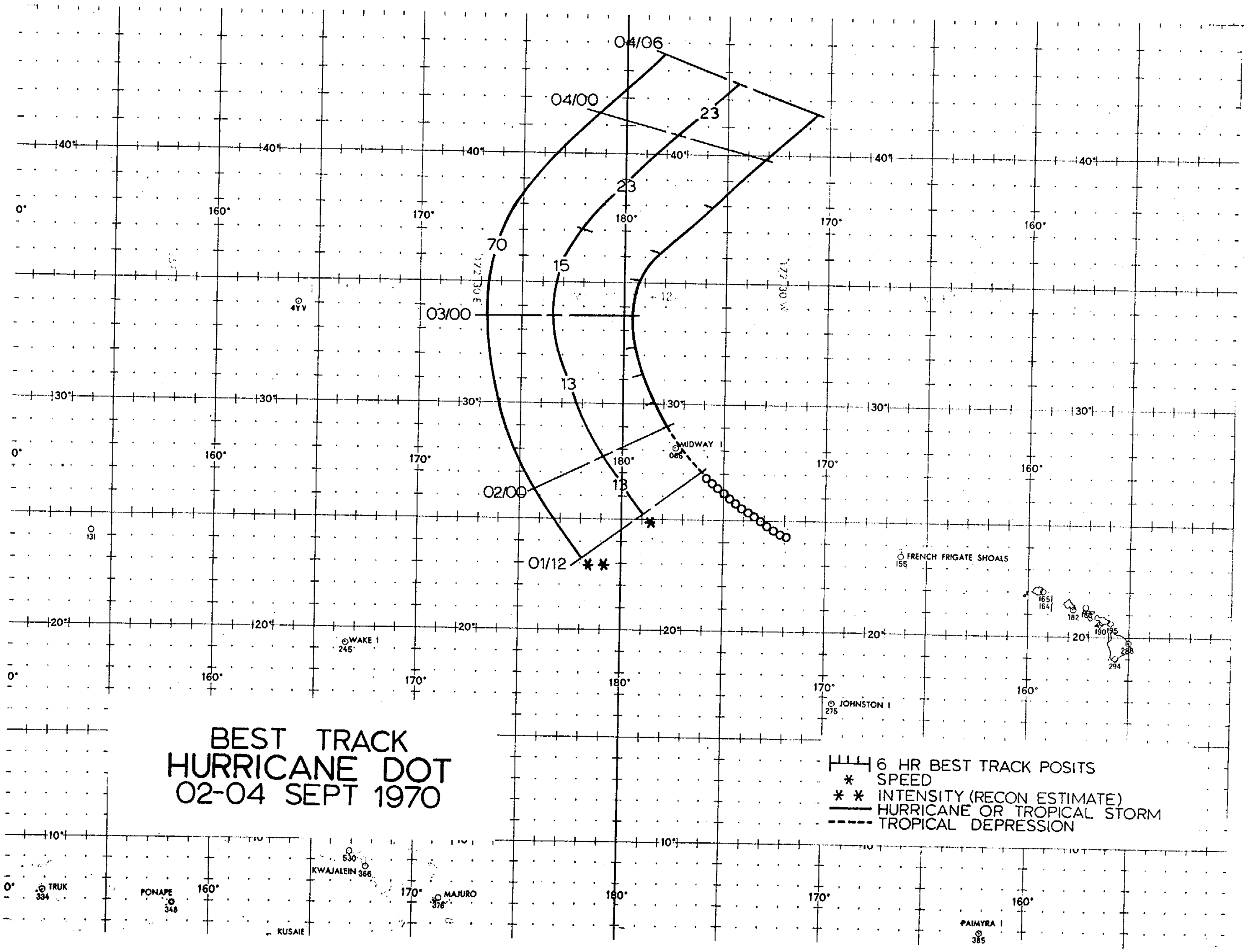
1. MINIMUM OBSERVED SLP - 993 MB.
2. MINIMUM OBSERVED 700 MB HEIGHT - 3015M.
3. MAXIMUM SURFACE WIND - 70 KTS.
4. MAXIMUM RADIUS OF SURFACE CIRCULATION - 200 MI.

II. DEVELOPMENT

A. INITIAL IMPETUS - INDUCED FROM UPPER LEVEL LOW
B. INITIAL SURFACE VORTEX - 012130Z ESSA VIII
C. TIME STORM REACHED HURRICANE INTENSITY - 030710Z

III. FINAL DISPOSITION

A. BECAME EXTRATROPICAL


BEST TRACK
HURRICANE DOT
02-04 SEPT 1970
6 HR BEST TRACK POSITS
SPEED
INTENSITY (RECON ESTIMATE)
HURRICANE OR TROPICAL STORM
TROPICAL DEPRESSION
04/06
04/00
03/00
02/00
01/12
70
15
13
23
13
23
MIDWAY I
FRENCH FRIGATE SHOALS
JOHNSTON I
WAKE I
KWAJALEIN
MAJURO
PONAPE
TRUK
KUSAIE
PALMYRA I

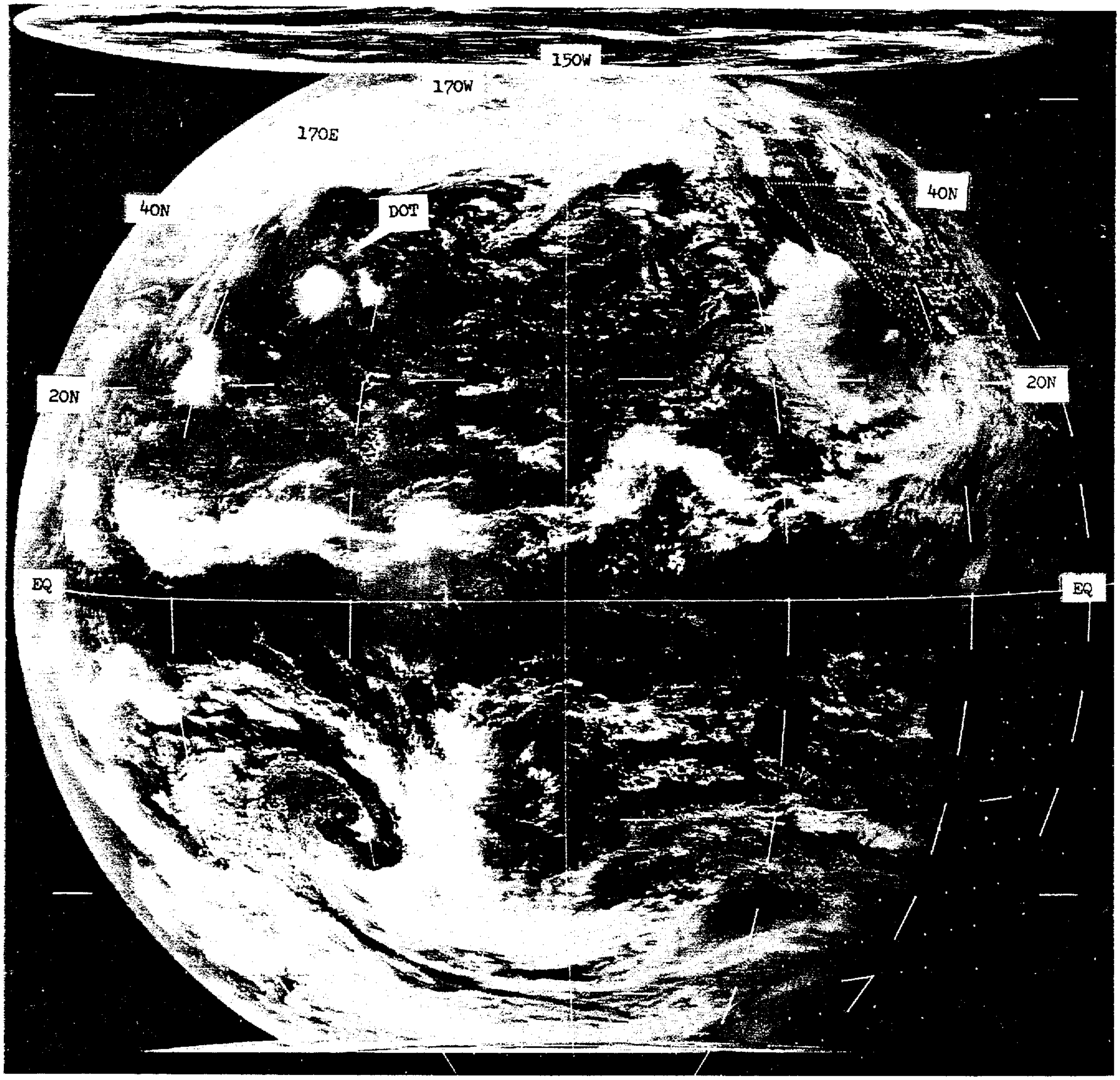


FIGURE AN-1

VIEW OF PACIFIC FROM GEOSTATIONARY SATELLITE ATS-1
DEPICTING TROPICAL STORM DOT
NORTH OF MIDWAY ISLAND

HURRICANE DOT

POSITION FROM BEST TRACK AND VERIFICATION DATA

	STORM POSIT		24 HR ERROR	48 HR ERROR	72 HR ERROR
TIME	LAT	LONG	DEG/DIST	DEG/DIST	DEG/DIST
021800Z	33.3N	179.7W	-	-	-
022300Z	33.4N	179.4W	-	-	-
030600Z	35.5N	179.0W	-	-	-
031200Z	36.6N	177.6W	-	-	-
031800Z	38.1N	175.5W	250/250	-	-
040000Z	39.8N	173.0W	230/400	-	-
040600Z	41.4N	170.5W	250/240	-	-

24 HOUR FORECAST ERROR = 297 MI
48 HOUR FORECAST ERROR = NOT APPLICABLE
72 HOUR FORECAST ERROR = NOT APPLICABLE

EYE FIXES HURRICANE DOT

FIX NO.	TIME	POSIT	UNIT-METHOD-ACCY	FLT LVL	FLT LVL WND	OBS SFC WND	OBS MIN SLP	MIN 700MB HGT	FLT LVL TT/TO	EYE FORM	EYE DIA
1	020244Z	29.5N 178.0W	SLTLS STG C+								
2	021835Z	33.4N 179.8W	VW-RDR-X-10		---	065	---	----	-- --	ELIP	14X24
3	022300Z	33.4N 179.4W	AF-X-X-X		---	040	999	3033	11/09	CIR	25
4	030146Z	33.0N 179.5W	SLTLS STG C+								
5	030700Z	35.3N 179.0W	AF-P--08	700MB	051	070	993	3015	12/10	CIR	20
6	031335Z	36.7N 177.6W	VW-P--05	700MB	067	---	---	----	14/09	CIR	25
7	040242Z	39.0N 173.0W	SLTLS STG C+								
8	040600Z	41.4N 170.5W	AF-X-X-X		(RECD VIA PHONE)						

APPENDIX

ABBREVIATIONS AND DEFINITIONS

The following abbreviations and definitions apply for the purposes of this report.

1. ABBREVIATIONS

AJTWC	Alternate Joint Typhoon Warning Center (Asian Weather Central, Fuchu, Japan)
APT	Automatic Picture Transmission
ATS	Applications Technology Satellite
CINCPAC	Commander in Chief, Pacific
CINCPACAF	Commander in Chief, Pacific Air Force
CINCPACFLT	Commander in Chief, Pacific Fleet
DRIR	Direct Readout Infrared Radiometer
MPT	Mid-Pacific Trough
NEDN	Naval Environmental Data Network
NESS	National Environmental Satellite Service (Suitland, Maryland)
NWRF (NAVWEARSCHFAC)	Navy Weather Research Facility (Norfolk, Virginia)
NWS/NOAA	National Weather Service, National Oceanic and Atmospheric Administration
PACOM	Pacific Command
SLP (MSLP)	Sea Level Pressure (Minimum Sea Level Pressure)
TCRC	Tropical Cyclone Reconnaissance Coordinator

2. DEFINITIONS

CYCLONE - An atmospheric closed circulation, rotating counterclockwise in the Northern Hemisphere.

TROPICAL CYCLONE - A non-frontal cyclone of synoptic scale, developing over tropical or sub-tropical waters and having a definite organized circulation and warm core.

TROPICAL DEPRESSION - A tropical cyclone in which the maximum sustained surface wind is 33 knots or less.

TROPICAL STORM - A tropical cyclone with maximum sustained surface winds in the range 34 to 63 knots inclusive.

TYPHOON/HURRICANE - A tropical cyclone with maximum sustained surface wind speeds 64 knots or greater. West of 180 degrees longitude the name TYPHOON is used and east of 180 degrees longitude the name HURRICANE is used. All descriptive references to typhoons apply equally to hurricanes.

SUPER TYPHOON - A typhoon with maximum sustained winds greater than or equal to 130 knots.

TROPICAL DISTURBANCE - A discrete system of apparently organized convection, generally 100 to 300 miles in diameter originating in the tropics or sub-tropics, having a non-frontal migratory character and having maintained its identity for 24 hours or more. It may or may not be associated with a detectable perturbation on the wind field. As such, it is the basic generic designation which, in successive stages of intensification, may be subsequently classified as a tropical depression, tropical storm or typhoon.

TROPICAL WAVE - A trough of cyclonic curvature maximum in the trade wind easterlies. The wave may reach maximum amplitude in the lower middle troposphere, or may be the reflection of an upper troposphere cold low or equatorward extension of the middle latitude trough.

EYE CENTER - "EYE" refers to the roughly circular central area of a well-developed tropical cyclone usually characterized by comparatively light winds and fair weather. If more than half surrounded by wall cloud, the word EYE is used; otherwise, the area is referred to as a CENTER.

WALL CLOUD - A densely organized, roughly circular structure of cumuliform clouds completely or partially surrounding the eye or center of a tropical cyclone.

MAXIMUM SUSTAINED WIND - Highest surface wind speed of a cyclone averaged over a one minute period of time.

EXTRATROPICAL - A term used in warnings and tropical summaries to indicate that a cyclone has lost its "tropical characteristics". The term implies both poleward displacement from the tropics and the conversion of the cyclone's dominant energy source from latent heat of condensation release to baroclinic processes.

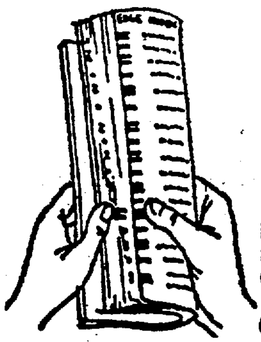
TROPICAL CYCLONE RECONNAISSANCE COORDINATOR - A CINCPACAF representative designated to levy tropical cyclone weather reconnaissance requirements on CINCPACFLT and CINCPACAF reconnaissance units within a designated area of PACOM and to function as a coordinator between CINCPACAF, weather reconnaissance units, and JTWC.

DISTRIBUTION

CNO (2)
COMSTS (1)
CINCPAC (2)
CINCPACFLT (2)
NAVOCEANO (2)
CINCLANTFLT (1)
COMNAVWEASERVCOM (40)
COMNAVSUPPFACDANANG (1)
COMNAVMARIANAS (1)
COMNAVPHIL (1)
COMNAVFORJAPAN (1)
COMSEVENTHFLT (10)
COMFIRSTFLT (1)
COMASWFORPAC (1)
COMNAVAIRPAC (17)
COMPHIBPAC (2)
COMNAVFACENGCOMPACDIV (1)
COMCRUDESPAC (1)
COMINFLOT ONE (1)
FLEWEACEN PEARL HARBOR (1)
FLEWEACEN ALAMEDA (1)
FLEWEACEN ROTA (1)
FLEWEACEN KODIAK (1)
FLEWEAFAC SUITLAND (1)
FLEWEAFAC SANGLEY POINT (2)
FLEWEAFAC YOKOSUKA (2)
FLEWEAFAC JACKSONVILLE (1)
FLEWEAFAC SAN DIEGO (1)
NESS SUITLAND (2)
NAVWEARSCHFAC (2)
FLENUMWEACEN (2)
AF GLOBAL WEACEN (2)
MCAS QUANG TRI (1)
NWSED ATSUGI (1)
NWSED NAHA (1)
NWSED SASEBO (1)
NWSED CUBI POINT (1)
NWSED AGANA (1)
NWSED BARBERS POINT (1)
NWESA DETACHMENT (FAMOS) (1)
NWSED ASHEVILLE (2)
SUPT, NAVPGSCOL (2)
AEWRON ONE (8)
WEARECONRON FOUR (2)
MCAS KANEOHE BAY (1)
MCAS IWAKUNI (2)
HQ, AWS, SCOTT AFB (10)
HQ, 1WW (50)
HQ, 9TH WEA RECON WG (2)
HQ, 1ST MARINE ACFT WNG (5)
HQ, 3 WW (1)
54WRS (10)
56WRS (2)
55WRS (1)
HQ, THIRD AIR DIV (8)
HQ, 315TH AIR DIV (1)
HQ, 313TH AIR DIV (1)
3345TH TECH SCHOOL CHANUTE (3)
MHRCA, NHC, MIAMI (1)
CHIEF, MUAG JAPAN (2)
CHIEF, MAAG TAIWAN (2)
CHINESE AF WEACEN TAIWAN (2)
ROYAL OBSERVATORY, HONG KONG (3)
LIBRARY OF CONGRESS (2)
CHINESE NAVAL WEACEN, TAIWAN (2)
DIA (1)
COMNAVFORV (1)
OLB 1WW (4)
DDR&E (1)

EDGE INDEX

HOW TO USE THE EDGE INDEX



Bend the book nearly double and hold it in your right hand as shown.

Locate the listing you want in the Edge Index.

Match up the 1 or 2 line symbol next to the listing you have selected with the corresponding 1 or 2 dot symbol on the page edge.

OPEN THERE.